BASICS FOR AIR TRAFFIC CONTROL – BASIC NAVIGATION

MODULE OVERVIEW

Purpose: The purpose of this module is to introduce the basics of navigation; the methods of navigation used by a pilot; and times, speeds, distances, and other factors associated with basic navigation.

MODULE OUTLINE

Lesson: Reference Lines

Purpose: The purpose of this lesson is to identify basic navigational reference lines and coordinates used to identify locations and measure distances.

Objectives:

- Identify reference lines of the Earth and their purpose
- Identify coordinates and distance measurements used in navigation

Topics:

- Reference Lines
  - Earth's Reference Lines
  - Parallels of Latitude
  - Longitude
- Coordinates and Distance Measurement
  - Coordinates
  - Latitude + Longitude
  - Circular Measurement
  - Measurement of Distance
  - Great Circle Route / Rhumb Line
- Knowledge Check
- Review/Summary

Question and Answer Session – *Parking Lot*

Exercise – Latitude and Longitude

Lesson: Time, Speed, and Distance Measurement Used to Calculate Navigation

Purpose: The purpose of this lesson is to identify the effects of altitude and temperature on speed and explain how to convert and calculate time, speed, and distance as they are used in navigation.

Objectives:

- Identify methods of conversion for time, speed, and distance
- Identify types of speed
- Identify effects of altitude and temperature on speed
- Identify methods of calculating time, speed, and distance

Topics:

- Time, Speed, and Distance Measurement
  - Measurement of Distance
  - Measurement of Speed
  - Conversion Formulas
- Measurements of Time
  - Coordinated Universal Time (UTC)
  - 24-Hour Clock
  - International Time Zones
- Time Conversion
  - U.S Time Zones
  - U.S. Time Conversion Factors
  - Standard Time Conversion Example
  - Daylight Time Conversion Example
- Knowledge Check
- Types of Speed
  - Indicated Airspeed (IAS)
  - True Airspeed (TAS)
  - Ground Speed (GS)
  - Mach Number (MACH)
- Effects of Altitude and Temperature on Speed
  - Speed
  - Effect of Altitude on Speed
  - Effect of Temperature on Speed
- Time, Speed, and Distance Computation
  - Time Formula
  - Speed Formula
  - Distance Formula
  - Finger Formula
- Knowledge Check
- Review/Summary

Question and Answer Session – *Parking Lot*

Game – Calculating Time, Speed, and Distance

Lesson: Factors Affecting Navigation

Purpose: The purpose of this lesson is to explain how wind and magnetic differences affect flight and to describe basic navigation methods used by pilots.

Objectives:

- Identify effects of wind on flight
- Identify magnetic variations and deviations
- Identify basic navigation methods

Topics:

- Factors Affecting Navigation
  - Wind
  - Ground Speed vs. True Airspeed
  - Effect of Drift
  - Effects of Wind on True Course, Track, and Drift Angle
  - True Heading (TH)
- Knowledge Check

- Magnetic Variation and Deviation
    - Magnetic Variation
    - Magnetic Deviation
- Knowledge Check
- Basic Navigation Methods
    - Dead Reckoning
    - Pilotage
- Knowledge Check
- Review/Summary

Question and Answer Session – *Parking Lot*

End-of-Module (EOM) Test

INTRODUCTION

LESSONS	■ Reference Lines ■ Time, Speed, and Distance Measurement Used to Calculate Navigation ■ Factors Affecting Navigation
TOTAL ESTIMATED RUN TIME	4 hrs. 27 mins.
MODULE CONTENT	■ Module Overview ■ Lesson: Reference Lines ■ Q&A Session – Parking Lot ■ Exercise: Latitude and Longitude ■ Lesson: Time, Speed, and Distance Measurement Used to Calculate Navigation ■ Q&A Session – Parking Lot ■ Game – Calculating Time, Speed, and Distance ■ Lesson: Factors Affecting Navigation ■ Q&A Session – Parking Lot ■ End-of-Module Test

FACILITATOR INSTRUCTIONS	DELIVERY METHOD
■ Instruct students to select ***Basic Navigation*** module link within Blackboard ■ Instruct students to read the module introduction and then wait quietly for additional instructions	Blackboard **EST. RUN TIME** 2 mins.

While you might not use applied navigation skills directly on the job as an air traffic controller, it is important to have a well-rounded aviation education, and this includes background knowledge of the concept of navigation.

Knowing the vocabulary and principles a pilot uses will serve you well in developing a better understanding of your job and how it fits into the overall aviation picture. Knowledge of basic navigation and the methods used by pilots will also provide you with guidelines to issue realistic clearance instructions.

The purpose of this module is to introduce the basics of navigation; the methods of navigation used by a pilot; and times, speeds, distances, and other factors associated with basic navigation.

FACILITATOR INSTRUCTIONS	DELIVERY METHOD
■ **ENABLE *Reference Lines*** lesson in Blackboard ■ Instruct students to navigate to the ***Reference Lines*** lesson in Blackboard ■ Instruct students to work individually through the lesson content ■ Upon completion of the lesson, students should review previously introduced content or wait quietly until other students have completed	Blackboard **EST. RUN TIME** 15 mins.

REFERENCE LINES

Purpose: The purpose of this lesson is to identify basic navigational reference lines and coordinates used to identify locations and measure distances.

Objectives:

- Identify reference lines of the Earth and their purpose
- Identify coordinates and distance measurements used in navigation

References for this lesson are as follows:

- FAA-H-8083-25, Pilot's Handbook of Aeronautical Knowledge
- FAA Order JO 7110.65, Air Traffic Control

Reference Lines

Earth's Reference Lines

The Earth is considered a true sphere divided by imaginary reference lines called parallels of latitude and meridians of longitude. These imaginary reference lines appear on the globe as a series of circles.

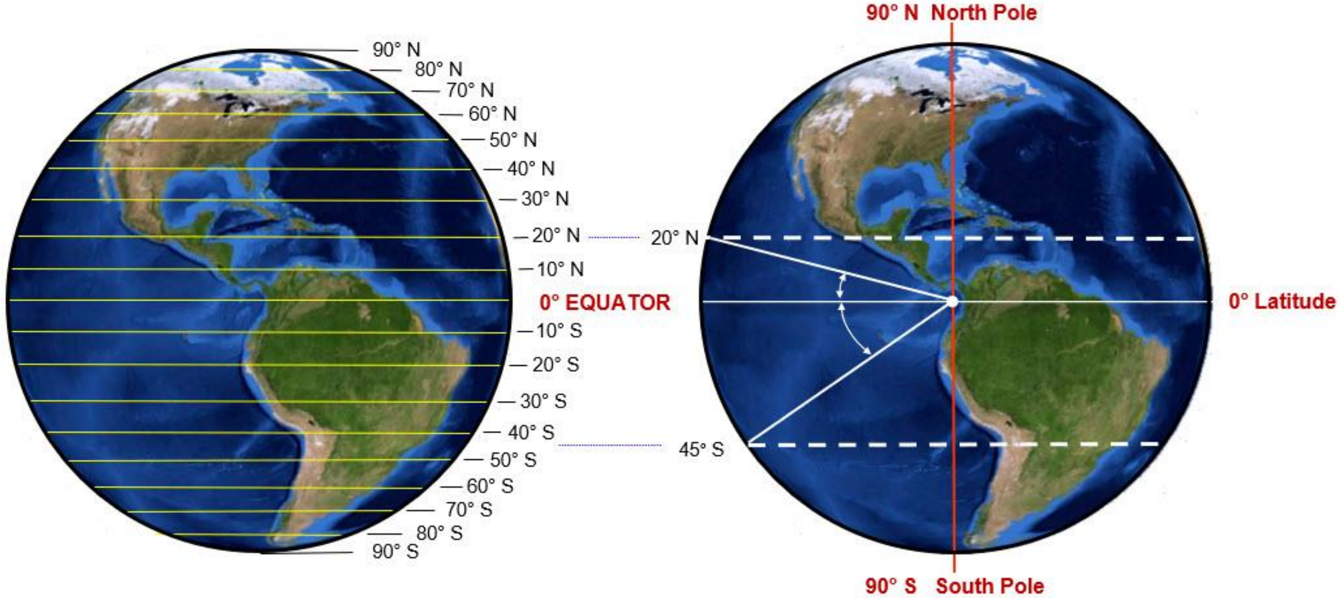
Parallels of Latitude

The equator is an imaginary circle, equidistant from the poles of the Earth. The equator is a great circle. A great circle is a circle, on the surface of a sphere, which lies in a plane passing through the sphere's center. It represents the shortest distance between any two points on a sphere.

Circles parallel to the equator (lines running east and west) are called parallels of latitude.

The equator is 0° latitude.

- North pole is 90° north latitude
- South pole is 90° south latitude

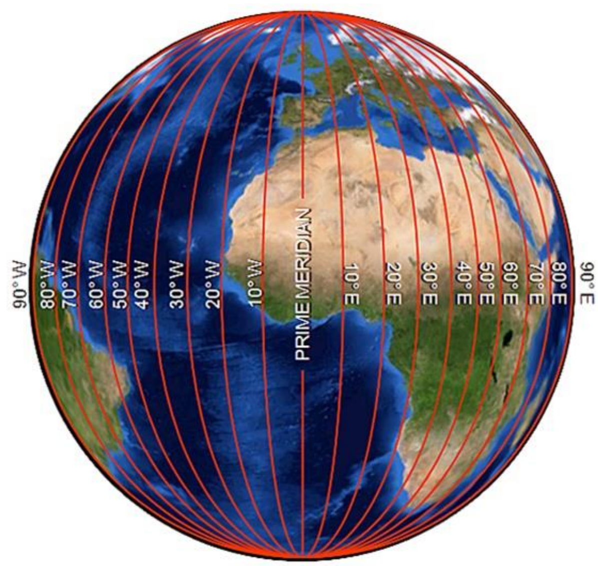


Longitude

The Prime Meridian is the reference line used to measure degrees of longitude.

The Prime Meridian runs through Greenwich, England, and is 0° longitude.

Meridians of longitude are used to measure angular (circular) distances, east and west of the Prime Meridian.

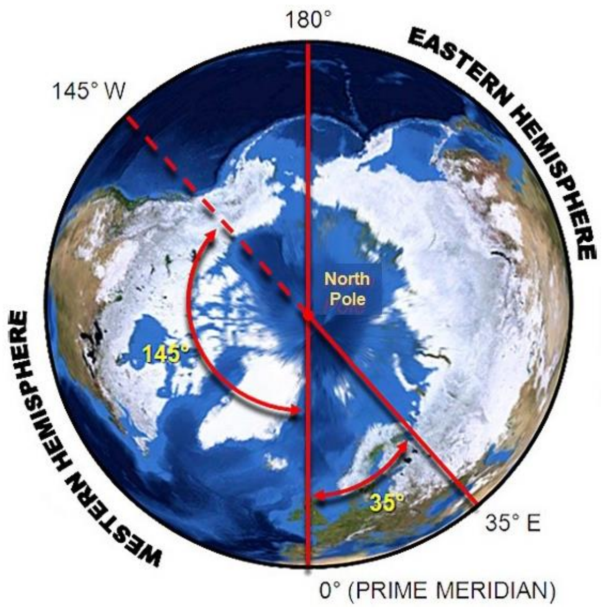


Longitude is numbered from 0° at the Prime Meridian to 180° east and 180° west.

180° east longitude and 180° west longitude are the same meridian.

All meridians of longitude converge at the Earth's poles.

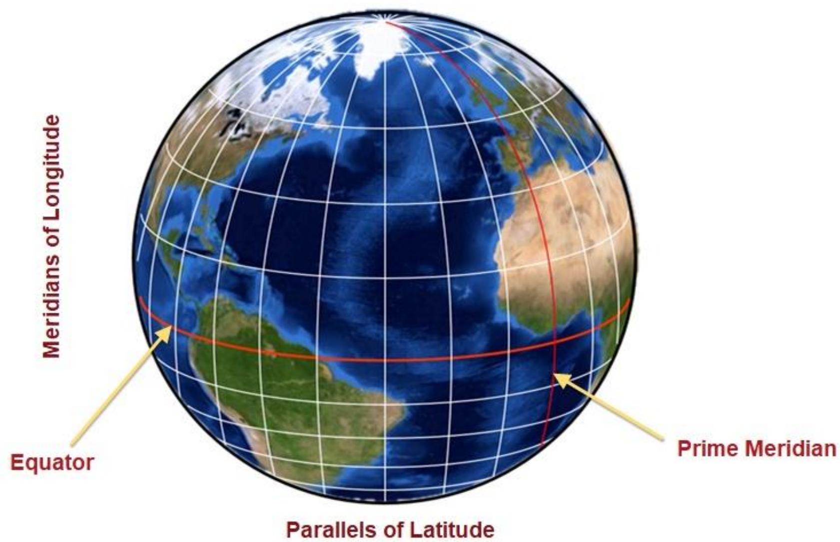
Note: *The meridian of longitude located at 180° was used to establish the International Date Line.*



Coordinates and Distance Measurement

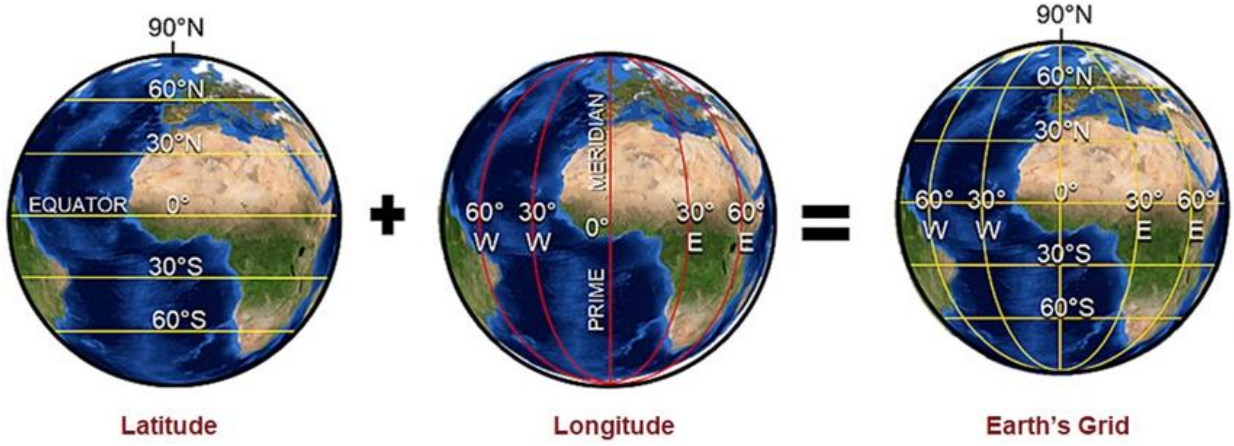
Coordinates

The places where meridians and parallels cross are called coordinates. Coordinates describe the positions of a navigational point on the Earth's surface consisting of parallels of latitude and meridians of longitude.



Coordinates are used:	■ In pilot charts and maps ■ To describe blocks of airspace ■ For airborne navigation systems
Coordinates in ATC:	■ Are written without degree or minute symbology ■ Do **NOT i**nclude seconds ***ATC Example:*** **3427N10536W** *Some publications list latitude/longitude using the decimal system.* ***Example**:* **34-27.73N 105-36.93W**

Latitude + Longitude



Circular Measurement

Parallels and meridians are divided into:

- Degrees
- Minutes
- Seconds

Latitude is always stated before longitude.

- Parallels of latitude are used for measuring degrees of latitude north and south of the equator
- Meridians of longitude are used for measuring degrees east and west of the Prime Meridian

Because of the geographic location of the U.S., to determine any location on any U.S. chart:

- Latitude readings increase from bottom to top
- Longitude readings increase from right to left

In the United States, latitude/longitude is read from bottom to top, right to left.

129 degrees, 40 minutes, 16 seconds

written

129°40'16"

A circle = 360 degrees (360°)
1 degree (1°) = 60 minutes (60')
1 minute (1') = 60 seconds (60")

29°40'16"N, 45°30'15"W

indicates

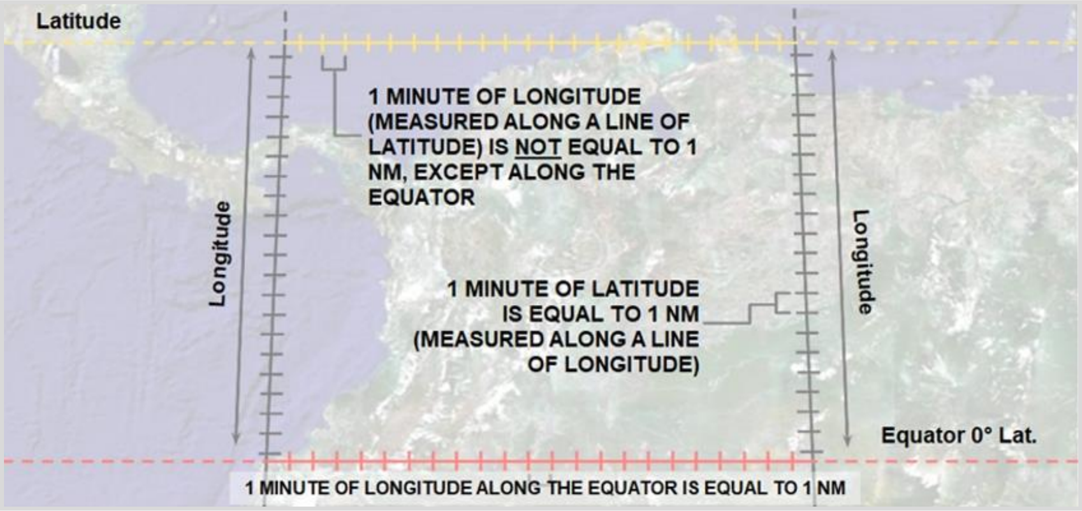
29 degrees, 40 minutes, 16 seconds north latitude, 45 degrees, 30 minutes, 15 seconds west longitude

Example of latitude/longitude reading in United States

Measurement of Distance

Longitude **cannot** be used as a scale to measure distance, except at the equator.

- One minute of longitude along the equator is equal to 1 nautical mile
- Meridians converge toward the poles as distance between lines changes

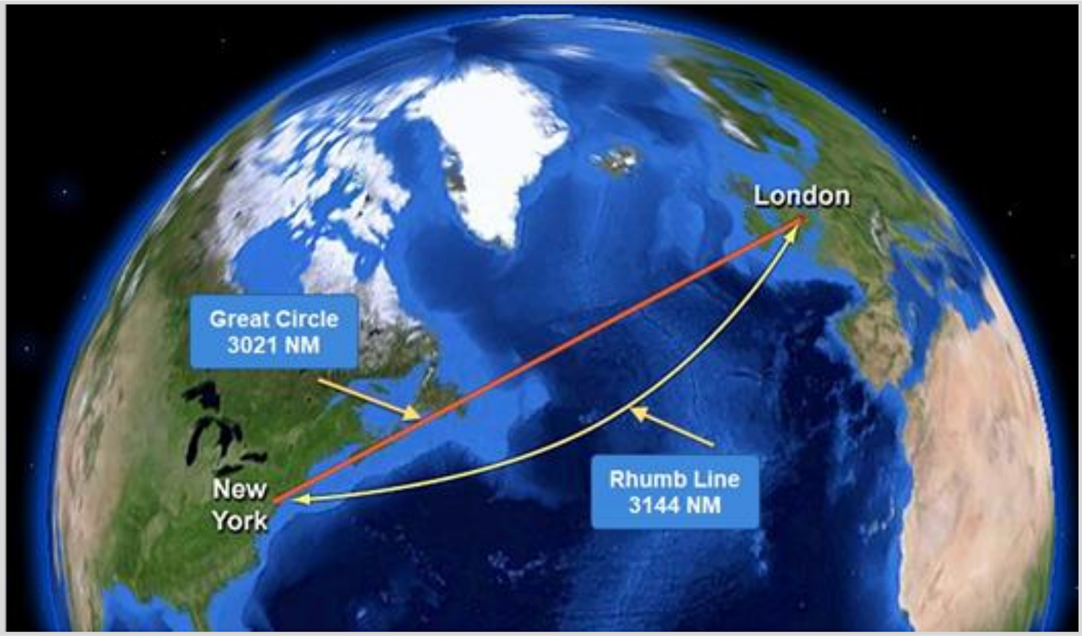


Great Circle Route / Rhumb Line

A great circle route is the shortest distance between two points on a sphere, such as the Earth.

- Most direct route over the Earth's surface
- Saves time and fuel
- Crosses every meridian at a different angle (constantly changing true direction)

A rhumb line is a line which makes the same angle with each meridian of longitude, and is longer than a great circle route.



An aircraft holding a constant heading would be flying a rhumb line.

- Requires more time and fuel because of the greater distance traveled
- Is easier to navigate because its direction remains constant

Note: *A great circle route adjusts to the curvature of the Earth; the rhumb line does* ***NOT.***

Knowledge Check A

REVIEW what you have learned so far about reference lines. ANSWER the questions listed below.

1. Which reference line is used to measure north-south distances? *(Select the correct answer.)*
   - ❑ Great circle
   - ❑ Prime Meridian
   - ❑ **<u>Equator</u>**
   - ❑ North pole

2. How many minutes are there in 1 degree of latitude? *(Select the correct answer.)*
   - ❑ 180
   - ❑ 360
   - ❑ 90
   - ❑ **<u>60</u>**

3. Match the reference line descriptions with the term. Enter your answers in the spaces below.

d	A series of circles parallel to the equator	a.	Longitudinal lines
c	Shortest distance between two points on a sphere	b.	Coordinates
b	Positions of a navigational point on the Earth's surface consisting of parallels of latitude and meridians of longitude	c.	Great circle route
a	Measure angular distance east and west of the Prime Meridian	d.	Parallels of latitude

4. Which of the following displays the correct reading of these coordinates? **29°40'N, 35°53'W** *(Select the correct answer.)*
   - ❑ 29 degrees, 40 degrees north (latitude), 35 degrees, 53 degrees west (longitude)
   - ❑ **<u>29 degrees, 40 minutes north (latitude), 35 degrees, 53 minutes west (longitude)</u>**
   - ❑ 40 minutes north (longitude), 29 degrees, 53 minutes west (latitude), 35 degrees
   - ❑ 29 degrees, 40 minutes north (longitude), 35 degrees, 53 minutes west (latitude)

Reference Lines Summary

Pilots use reference lines and coordinates as they travel along routes to their destinations. As a controller, you must have a basic understanding of navigational terms and principals in order to provide guidance and instructions.

FACILITATOR INSTRUCTIONS	DELIVERY METHOD
■ Review content presented in ***Reference Lines*** ■ Navigate to the ***Parking Lot*** link within Blackboard and review any student questions ■ Address ***Parking Lot*** questions and facilitate a brief discussion of the lesson content	Facilitated Discussion **EST. RUN TIME** 20 mins.

FACILITATOR INSTRUCTIONS	DELIVERY METHOD
■ Instruct students to locate the student exercise ***Latitude and Longitude*** in the printed ***Student Guide*** ■ Instruct students to locate VFR Raster Charts ***(Dallas-Fort Worth, Cheyenne, and Green Bay Sectionals)*** in the ***Student Guide and References*** folder ■ Inform students to use references to answer questions ■ The exercise will be performed in groups of two ■ Instruct students to answer each question ■ At the end of the exercise, the exercise will be evaluated during a whole class discussion ■ Randomly select students to provide answers orally ■ Instruct other students to assess their answers when provided ■ Encourage student discussion with this exercise and resolve any questions	Exercise **EST. RUN TIME** 45 mins.

EXERCISE: LATITUDE AND LONGITUDE

Purpose
This exercise provides practice locating items on a chart using only latitude and longitude information.

Detailed Facilitator Instructions: *The references required to complete this exercise are located in the* ***Basic Navigation, Student Guide and References*** *folder. Ensure students have located the references before beginning the exercise. Direct students to work in groups of two to answer the following questions. After completion, select students randomly to provide answers orally while other students assess their own answers. Encourage student discussion with this exercise and resolve any questions the students may have on the exercise or reading VFR Raster Charts.*

Directions

Using VFR Raster Charts, locate the associated landmarks using the latitude and longitude coordinates.

References

- Dallas-Fort Worth Sectional
- Cheyenne Sectional
- Green Bay Sectional

COORDINATES	LANDMARK
Questions 1-5: Use Dallas-Fort Worth Sectional	
1. 3533N, 10138W	**Turkey Creek Pumping Station**
2. 3443N, 9713W	**Pauls Valley Airport**
3. 3425N, 9903W	**Cemetery**
4. 3552N, 9857W	**A wind farm**
5. 3526N, 10012W	**Wheeler Airport**
Questions 6-10: Use Cheyenne Sectional	
6. 4222N, 10607W	**Ranch**
7. 4215N, 10526W	**Laramie Peak**
8. 4056N, 10240W	**Julesburg Reservoir**
9. 4027N, 10759W	**Juniper Hot Springs**
10. 4425N, 10323W	**Sturgis Airport**
Questions 11-15: Use Green Bay Sectional	
11. 4504N, 8927W	**Two tall lighted obstructions**
12. 4605N, 8838W	**Stambaugh Airport**
13. 4804N, 9254W	**Pelican Lake**
14. 4508N, 8812W	**White Potato Lake**
15. 4605N, 9153W	**Golf course**

FACILITATOR INSTRUCTIONS	DELIVERY METHOD
■ **ENABLE *Time, Speed, and Distance Measurement Used to Calculate Navigation*** lesson in Blackboard ■ Instruct students to navigate to the ***Time, Speed, and Distance Measurement Used to Calculate Navigation*** lesson in Blackboard ■ Instruct students to work individually through the lesson content ■ Upon completion of the lesson, students should review previously introduced content or wait quietly until other students have completed	Blackboard **EST. RUN TIME** 25 mins.

TIME, SPEED, AND DISTANCE MEASUREMENT USED TO CALCULATE NAVIGATION

Purpose: The purpose of this lesson is to identify the effects of altitude and temperature on speed and explain how to convert and calculate time, speed, and distance as they are used in navigation.

Objectives:

- Identify methods of conversion for time, speed, and distance
- Identify types of speed
- Identify effects of altitude and temperature on speed
- Identify methods of calculating time, speed, and distance

References for this lesson are as follows:

- FAA-H-8083-25, Pilot's Handbook of Aeronautical Knowledge
- Aeronautical Information Manual (AIM)
- FAA Order JO 7110.65, Air Traffic Control

Time, Speed, and Distance Measurement

Time, speed, and distance are all calculated to ensure accurate navigation.

Measurement of Distance

Nautical miles (NM) must be used for all mileage in Instrument Flight Rules (IFR) planning and operations. It is also used in conjunction with federal airways and is used for aircraft separation rules.

Statute miles (SM) must be used for visibility.

Nautical Mile	1 NM is equal to: ■ **6,076.1** feet (Most references show 6,080 feet) ■ **1.15** SM ■ 1 minute of latitude
Statute Mile	1 SM is equal to: ■ **5,280** feet ■ **0.87** NM

Measurement of Speed

Speed is measured in knots.

Knot (kt):

- 1 NM per hour
- NMs and kts are universal in air traffic control (ATC)

Conversion Formulas

To convert miles, use one of the following formulas:

Conversion Factors	
1 NM = 1.15 SM	1 SM = 0.87 NM
To CONVERT, use one of the following formulas: NM x 1.15 = SM SM x .87 = NM	
Examples: 20 NM x 1.15 = 23 SM 50 SM x .87 = 43.5 NM	
Rule of Thumb: SMs will always be greater than NMs.	

Measurements of Time

In this section, three measurements of time will be presented.

- Coordinated Universal Time (UTC)
- 24-hour clock
- Time zones

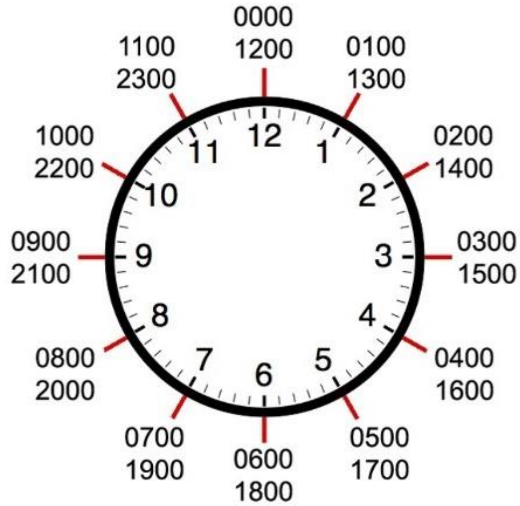
Coordinated Universal Time (UTC)

The local standard time at Greenwich, England, is the time reference used in aviation operations throughout the world.

- Also referred to as “Zulu” time when ATC procedures require a reference to UTC
- Used by the FAA for all operations; however, Visual Flight Rules (VFR) pilots may use local time
- Eliminates confusion caused by different local times

24-Hour Clock

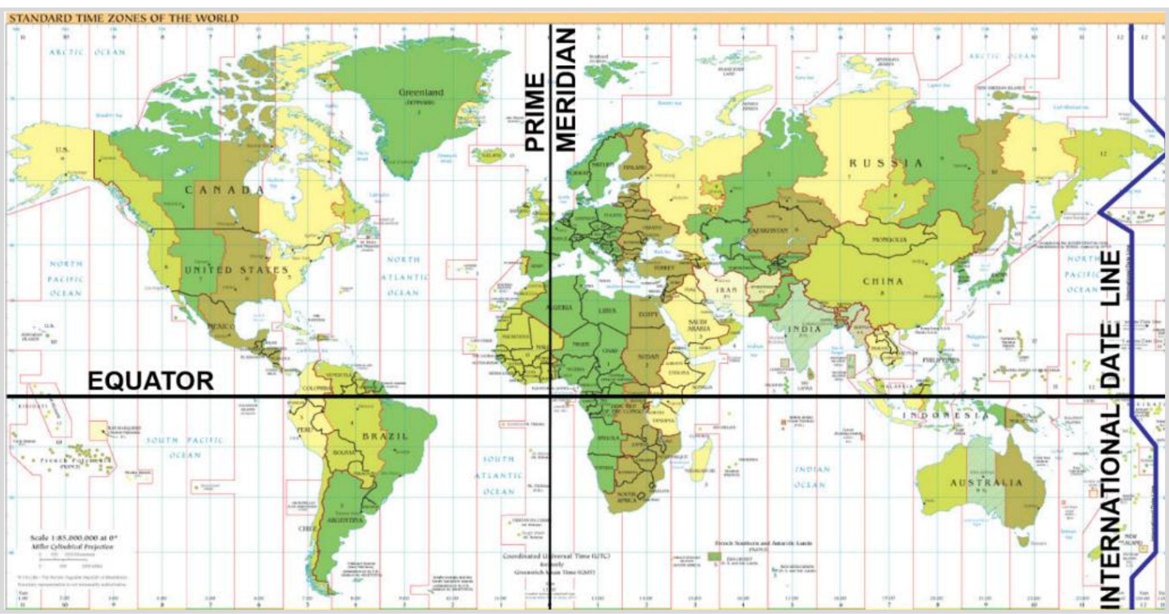
Using a 24-hour clock avoids confusion between AM and PM and is expressed using four digits.



International Time Zones

The Earth is divided into 24 standard time zones beginning at 0° longitude.

- Each zone is 15° of longitude wide starting at the Prime Meridian, with some variation due to geographical boundary considerations
- Time in each zone is called Local Standard Time/Daylight Savings Time (LST/DST)

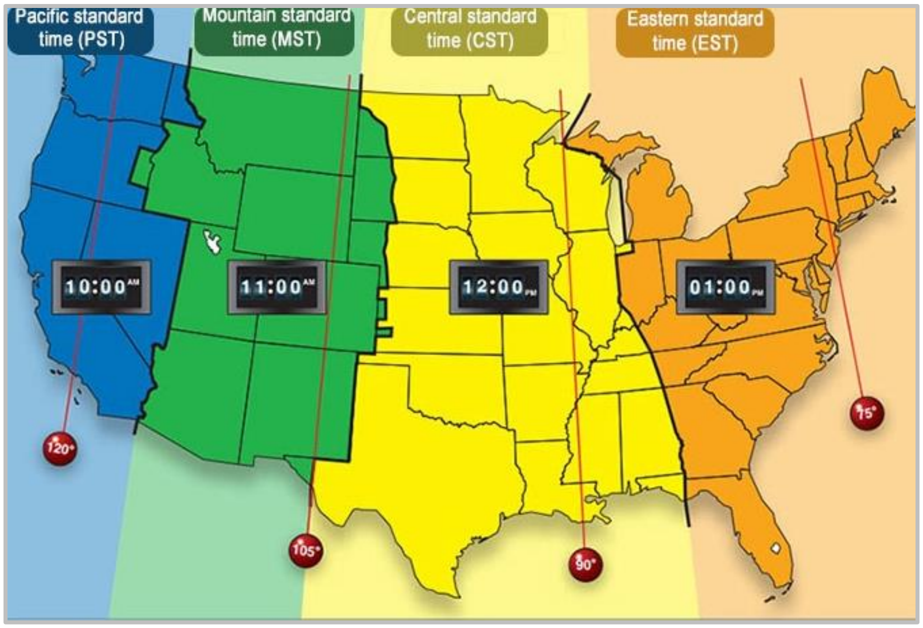


Time Conversion

ATC must factor in time conversion on a regular basis when providing guidance and separation.

U.S. Time Zones

There are four standard time zones in the contiguous U.S.



U.S. Time Zones Conversion Factors

To convert from LST to UTC, first convert to 24-hour clock, then determine appropriate conversion factor and apply.

U.S. Time Conversion Factors		
	Standard	**Daylight**
Eastern Time	+5 hours	+4
Central Time	+6 hours	+5
Mountain Time	+7 hours	+6
Pacific Time	+8 hours	+7
Alaska Time	+9 hours	+8
Hawaii Time	+10 hours	+9

Standard Time Conversion Example

11:00 AM CST + 6 hours conversion factor
1700Z in Greenwich, England
9:00 PM CST + 6 hours conversion factor
0300Z on the following day in Greenwich, England

Daylight Time Conversion Example

11:00 AM Central Daylight Time (CDT) + 5 hours conversion factor
1600Z in Greenwich, England
9:00 PM CDT + 5 hours conversion factor
0200Z on the following day in Greenwich, England

Note: *Daylight Savings Time (DST) starts at 2 AM the second Sunday in March and ends at 2 AM on the first Sunday in November. Some locations do not switch to DST.*

Knowledge Check B

REVIEW what you have learned so far about time, speed, and distance used to calculate navigation. ANSWER the questions listed below.

1. The unit of measurement that equals 1 NM is _____ SM. *(Select the correct answer.)*
   - ❑ 0.87
   - ❑ **1.15**
   - ❑ 1.5

2. A time zone is established for every _____. *(Select the correct answer.)*
   - ❑ **15 degrees of longitude**
   - ❑ 7 ½ degrees of latitude
   - ❑ 15 degrees of latitude

3. An aircraft departs Oklahoma City at 9 PM (CST) and travels for 3 hours to arrive in Seattle, WA (PST). What was the aircraft's arrival time UTC? *(Select the correct answer.)*
   - ❑ 0500Z
   - ❑ 6:00 PM
   - ❑ **0600Z**

U.S. Time Conversion Factors	
	Standard
Eastern Time	+5 hours
Central Time	+6 hours
Mountain Time	+7 hours
Pacific Time	+8 hours
Alaska Time	+9 hours
Hawaii Time	+10 hours

4. If it is 1300Z in Philadelphia (EST), what local time would it be in San Francisco (PST)? *(Select the correct answer.)*
   - ❑ 1100Z
   - ❑ **5:00 AM**
   - ❑ 2:00 PM

U.S. Time Conversion Factors	
	Standard
Eastern Time	+5 hours
Central Time	+6 hours
Mountain Time	+7 hours
Pacific Time	+8 hours
Alaska Time	+9 hours
Hawaii Time	+10 hours

5. At 1 PM EDT in New York City, the time is _____ UTC. (Conversion factor is +5 EST.) *(Select the correct answer.)*
   - ❑ 1600
   - ❑ **1700**
   - ❑ 1800

U.S. Time Conversion Factors	
	Standard
Eastern Time	+5 hours
Central Time	+6 hours
Mountain Time	+7 hours
Pacific Time	+8 hours
Alaska Time	+9 hours
Hawaii Time	+10 hours

Types of Speed

There are four types of speed used in aviation:

Indicated Airspeed (IAS)	■ Shown on the aircraft's airspeed indicator ■ Used in pilot/controller communications
True Airspeed (TAS)	Relative to undisturbed air mass and used in: ■ Flight planning ■ En route portion of flight
Ground Speed (GS)	■ The speed of an aircraft relative to the surface of the Earth ■ TAS corrected for the effects of wind
Mach Number (MACH)	■ Ratio of TAS to the speed of sound, expressed in decimal form ■ Mach 0.82 or Mach 1.6

Effects of Altitude and Temperature on Speed

Both altitude and temperature affect speed in ways that must be carefully considered by both the pilot and the controller.

Speed

Pilots use performance tables to calculate their true airspeed from power settings, altitude, and temperature.

- Calculating the wind's effect on true airspeed gives the pilot ground speed, which is then used to determine:
  - Time en route
  - Estimated time of arrival (ETA)

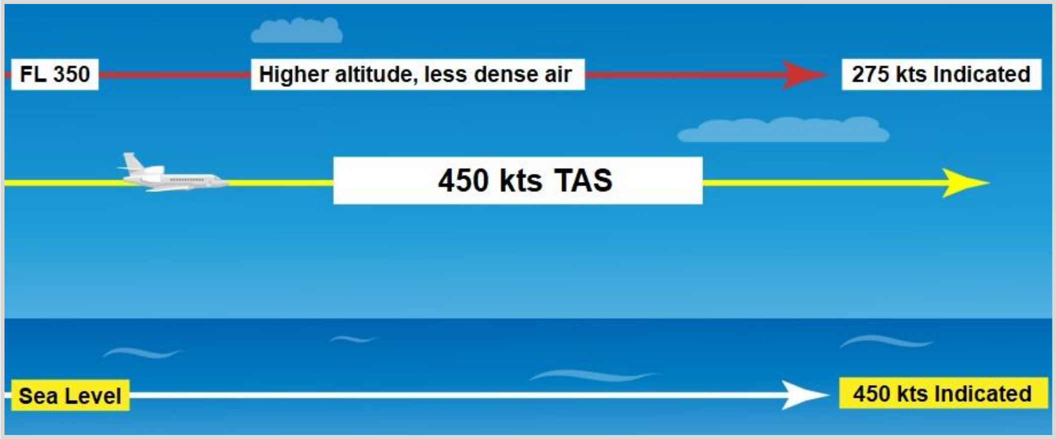
More importantly to a controller, for a constant true airspeed, the indicated airspeed decreases with increases in altitude and temperature.

- Because speeds assigned by ATC are expressed as knots of indicated airspeed, controllers need to be aware of the possible differences between true airspeed and indicated airspeed

Effect of Altitude on Speed

In the less dense air at higher altitudes, fewer air molecules enter the aircraft's pitot tube, resulting in a lower indicated airspeed reading.

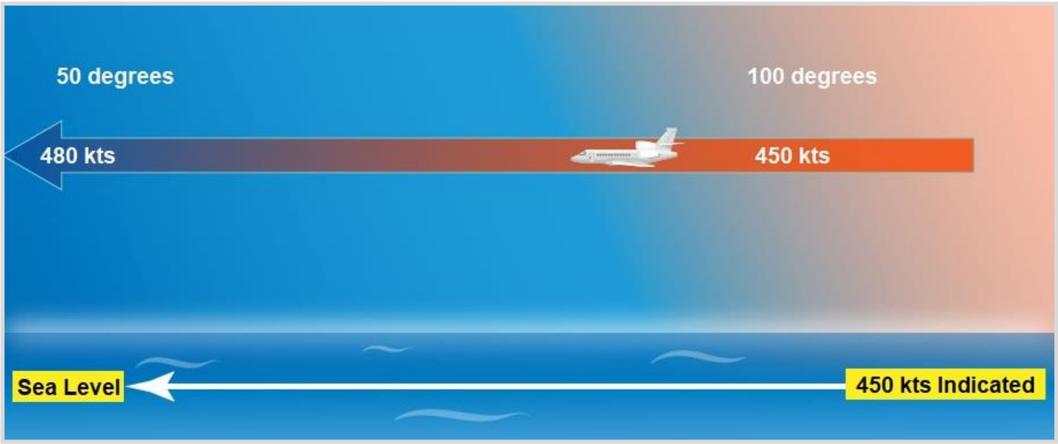
- At altitudes near sea level, there is little discernable difference between an aircraft's true airspeed and its indicated airspeed
- At high altitudes, an aircraft's indicated airspeed is significantly lower than its true airspeed



Effect of Temperature on Speed

As it does with increasing altitude, air becomes less dense as temperature increases.

- As a result, an increase in temperature has the same effect on speed as an increase in altitude
- Unlike the effects of altitude on speed, the difference between indicated airspeed and true airspeed caused by changes in temperature is relatively small and is less significant to a controller



Time, Speed, and Distance Computation

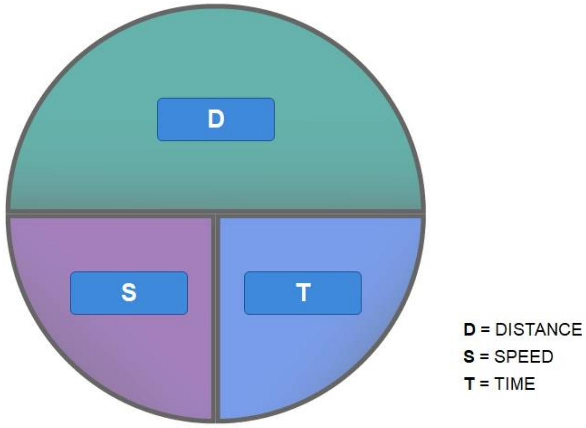
In air traffic control, time, speed, and distance will need to be calculated on a regular basis. Remember that only like units can be used together in a formula.

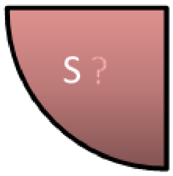
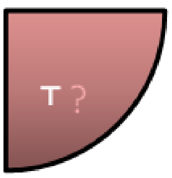
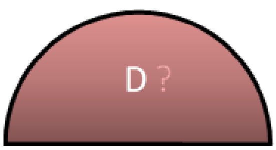
- If you use NMs, you must use kts
- If you use SM, you must use MPH
- If you use hours, you will get units per hour, and if you use minutes, you will get units per minute, etc.

Time Formula  $\text{TIME} = \frac{\text{DISTANCE}}{\text{SPEED}}$	Time = Distance divided by Speed **(T = D / S)** Time is measured in hours and minutes and must be converted to decimals in order to apply this formula. Divide minutes by 60 to get the decimal equivalent of hours and minutes. ***Example:*** *An airplane flew from OKC to ICT – a distance of 150 miles at an average speed of 60 kts. How long did it take?* Time = Distance ÷ Speed 150 divided by 60 = 2.5 hours ***Note:*** *2.5 hours is expressed as 2+30 in ATC. (Ensure students understand this concept.)*
Speed Formula  $\text{SPEED} = \frac{\text{DISTANCE}}{\text{TIME}}$	Speed = Distance divided by Time **(S = D ÷ T)** ***Example:*** *An aircraft flew a distance of 140 miles in 3 hours and 30 minutes (3.5 hours). What was the aircraft speed?* Speed = Distance ÷ Time 140 divided by 3.5 = 40 kts
Distance Formula  DISTANCE = SPEED x TIME	Distance = Speed multiplied by time **(D = S x T)** ***Example:*** *An aircraft flew at a speed of 60 kts for 2 hours and 15 minutes (2.25 hours). How far did the aircraft fly?* Distance = Speed x Time 60 x 2.25 = 135 miles

Finger Formula

The following "finger formula" is helpful in remembering this relationship. Place a finger over the unknown you wish to find and read the correct formula.



	To calculate **speed**, place your finger over S and read: **D / T or Distance / Time**
	To calculate **time**, place your finger over T and read: **D / S or Distance / Speed**
	To calculate **distance**, place your finger over D and read: **S x T or Speed x Time**

Knowledge Check C

REVIEW what you have learned so far about time, speed, and distance used to calculate navigation. ANSWER the questions listed below.

1. For what reasons does a pilot calculate the wind's effect on true airspeed? *(Select all correct answers that apply.)*
   - ❑ Calculate indicated airspeed
   - ❑ **Determine estimated time of arrival**
   - ❑ Figure out fuel consumption
   - ❑ **Determine time en route**

2. At high altitudes, an aircraft's indicated airspeed is _____ its true airspeed. *(Select the correct answer.)*
   - ❑ Higher than
   - ❑ The same as
   - ❑ **Lower than**

3. Which is the correct formula used for calculating time? *(Select the correct answer.)*
   - ❑ **TIME = Distance / Speed**
   - ❑ TIME = Speed / Distance
   - ❑ TIME = Speed x Distance

4. Which is the correct formula used for calculating distance? *(Select the correct answer.)*
- ❑ DISTANCE = Time / Speed
- ❑ DISTANCE = Speed / Time
- ❑ **DISTANCE = Speed x Time**

Time, Speed, and Distance Measurement Used to Calculate Navigation Summary

Time, speed, and distance must be calculated carefully and consistently. Practice using the formulas in this lesson so you can be proficient. This will be an important part of your everyday duties.

FACILITATOR INSTRUCTIONS	DELIVERY METHOD
▪ Navigate to the ***Time, Speed, and Distance Measurement Used to Calculate Navigation*** content ▪ Navigate to the ***Parking Lot*** link within Blackboard and review any student questions ▪ Address ***Parking Lot*** questions and facilitate a brief discussion of the lesson content	Facilitated Discussion **EST. RUN TIME** 20 mins.

FACILITATOR INSTRUCTIONS	DELIVERY METHOD
▪ **ENABLE *Calculating Time, Speed, and Distance*** game in Blackboard ▪ Instruct students to navigate to the ***Exercises and Activities*** folder in Blackboard ▪ Instruct students to locate ***Calculating Time, Speed, and Distance*** game located in this folder ▪ The game will be performed individually ▪ Instruct students to answer each question ▪ The game will evaluate the students' performance at the end ▪ Suggest allowing opportunities to repeat the game during periods of down time	Game **EST. RUN TIME** 20 mins.

GAME: CALCULATING TIME, SPEED, AND DISTANCE (ANSWER KEY)

Note: *The questions in the key and their distractors may appear in a different order than displayed here due to game question randomization.*

<table>
<tr><th>Question</th><th>Answer</th></tr>
<tr><td>1. Calculate time, speed, or distance using the calculator for the missing information in the table.</td><td><table>
<tr><th>Time</th><th>Speed</th><th>Distance</th></tr>
<tr><td>1+30 HRS</td><td>90 MPH</td><td>135 SM</td></tr>
<tr><td>9+00 HRS</td><td>150 kts</td><td>1350 NM</td></tr>
<tr><td>2+00 HRS</td><td>135 kts</td><td>270 NM</td></tr>
<tr><td>0+30 HRS</td><td>176 MPH</td><td>88 SM</td></tr>
</table></td></tr>
<tr><td>2. Calculate time, speed, or distance using the calculator for the missing information in the table.</td><td><table>
<tr><th>Time</th><th>Speed</th><th>Distance</th></tr>
<tr><td>1+45 HRS</td><td>240 MPH</td><td>420 SM</td></tr>
<tr><td>5+00 HRS</td><td>75 kts</td><td>375 NM</td></tr>
<tr><td>4+30 HRS</td><td>90 kts</td><td>405 NM</td></tr>
<tr><td>3+15 HRS</td><td>200 MPH</td><td>650 SM</td></tr>
</table></td></tr>
<tr><td>3. If this PA38 takes 2:00 hours to travel 274 NM from San Antonio-SAT to Houston-HOU, at what speed would it travel?</td><td>**137 knots**
127 knots
147 knots</td></tr>
<tr><td>4. How long would it take to fly roundtrip from Huntsville-HSV to Kansas City-MCI traveling at 122 knots? The distance between the two points is 700 SM.</td><td>**10 hours**
5 hours
11.5 hours</td></tr>
<tr><td>5. A C310 is flying from Jackson-JAN to Atlanta-ATL at 140 MPH. The total distance is 560 miles. How long did it take the aircraft to fly from JAN to ATL?</td><td>**4 hours**
2 hours
6 hours</td></tr>
<tr><td>6. A BE40 made four trips between 2 airports totaling 480 NM. The time required for one trip was 30 minutes. What was the speed of the aircraft?</td><td>**240 knots**
360 knots
120 knots</td></tr>
<tr><td>7. How many NM would this PAY3 fly during a 7 hour flight, if it was traveling at a speed of 200 knots?</td><td>**1400 NM**
900 NM
1200 NM</td></tr>
<tr><td>8. This BE35 is flying from Daytona Beach-DAB to Knoxville-TYS, approximately 450 NM. It flies 1/3 of the way in 1.5 hours. What was the speed of the aircraft?</td><td>**100 knots**
150 knots
50 knots</td></tr>
<tr><td>9. How long would it take to travel 300 SM between Louisville-LOU to Mobile-MOB if this BE20 was flying at 200 MPH?</td><td>**1.5 hours**
.75 hours
1 hour</td></tr>
<tr><td>10. If this C208 is traveling 740 NM from Oklahoma City-OKC to Yellowstone Regional Airport-COD and departs at 1100Z, what time would it reach COD flying at 170 MPH?</td><td>**1600Z**
1430Z
1500Z</td></tr>
</table>

Question	Answer
11. If a C421 departs from Covington-CVG at 0700Z and arrives in Huntsville-HSV at 0930Z flying at a rate of 150 MPH, how many SM did it cover?	**375 SM** 300 SM 105 SM
12. This C750 flew from Los Angeles International Airport-LAX to Portland International Airport-PDX at an average cruise speed of 575 MPH. How long did it take to make this flight of 863 SM?	**1.5 hours** 2 hours 1 hour

FACILITATOR INSTRUCTIONS	DELIVERY METHOD
■ **ENABLE *Factors Affecting Navigation*** lesson in Blackboard ■ Instruct students to navigate to the ***Factors Affecting Navigation*** lesson in Blackboard ■ Instruct students to work individually through the lesson content ■ Upon completion of the lesson, students should review previously introduced content or wait quietly until other students have completed	Blackboard **EST. RUN TIME** 25 mins.

FACTORS AFFECTING NAVIGATION

Purpose: The purpose of this lesson is to explain how wind and magnetic differences affect flight and to describe basic navigation methods used by pilots.

Objectives:

- Identify effects of wind on flight
- Identify magnetic variations and deviations
- Identify basic navigation methods

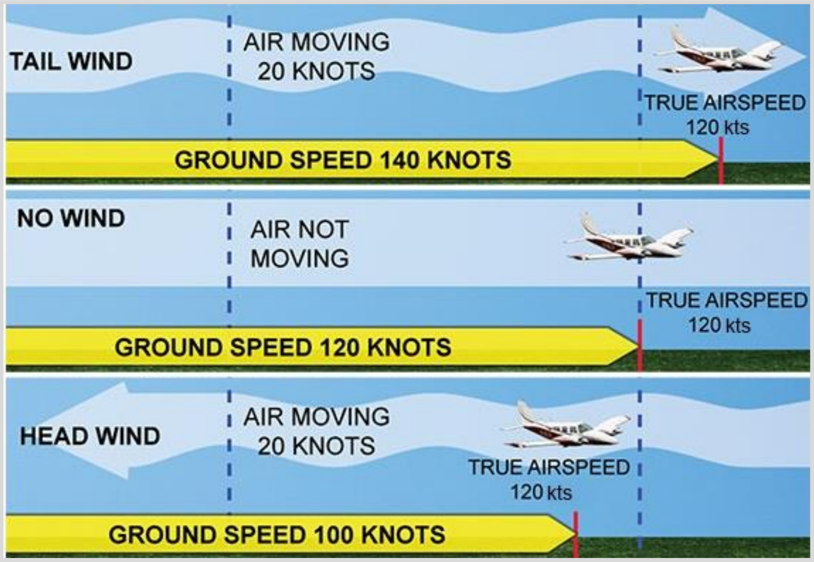
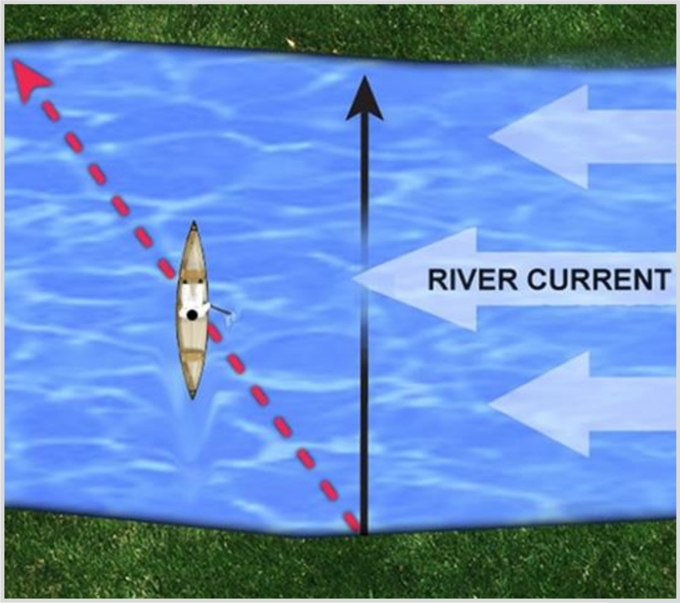
References for this lesson are as follows:

- FAA-H-8083-25, Pilot's Handbook of Aeronautical Knowledge
- Aeronautical Information Manual (AIM)

Factors Affecting Navigation

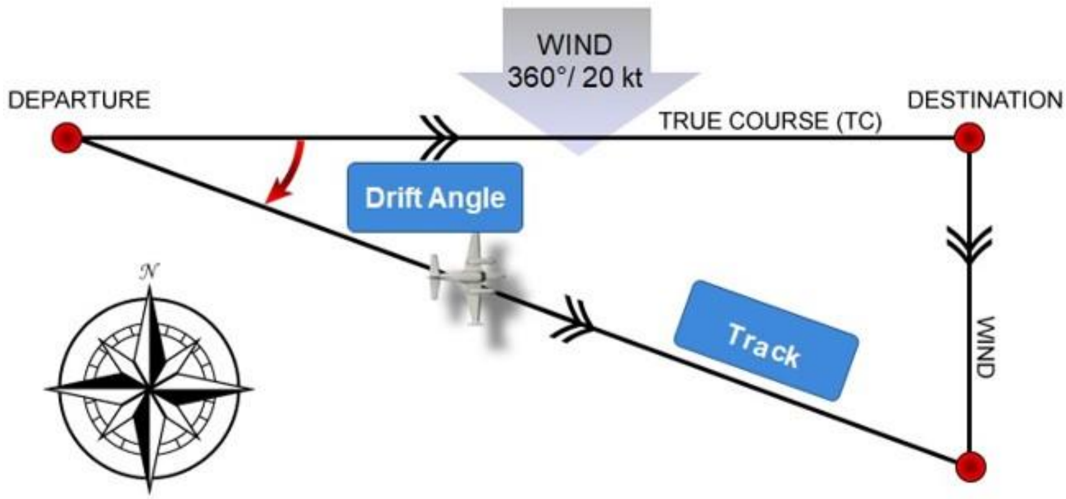
The following are affected by wind:

- Ground speed (GS) vs. true airspeed (TAS)
- True course (TC)
- Track
- Drift angle
- True Heading (TH)

Wind Wind is a mass of air moving over the Earth's surface in a definite direction. ■ Wind is stated to include the following: • Direction from which the wind is blowing • Velocity in knots **Example:** A wind report of 04025 is coming **from** 040 degrees at 25 knots.	
Ground Speed vs. True Airspeed Wind does **NOT** affect TAS. Wind does affect GS. ■ Increased by tailwind ■ Reduced by headwind Crosswind affects speed and direction of flight.	
Effect of Drift An aircraft's movement over the ground is comparable to a boat crossing a river. ■ If there is no current in the river, a boat starting at one shore of the river and rowing perpendicularly to the river's edge would end up at a point on the opposite shore directly across from its starting point ■ However, if there is a current, the boat will be carried downstream until the boat eventually reaches the opposite shore ■ The drift of the boat downstream is dependent upon the: • Direction and speed of the river current • Direction the boat is headed • Speed of the boat through the water	

Effects of Wind on True Course, Track, and Drift Angle

True course (TC) represents the intended path of the aircraft over the Earth's surface.



Drift angle is what any free object will do as the air moves downwind with the speed of the wind.

- This is just as true of an aircraft as it is of a balloon
- In one hour, an aircraft will drift downwind an amount equal to wind speed

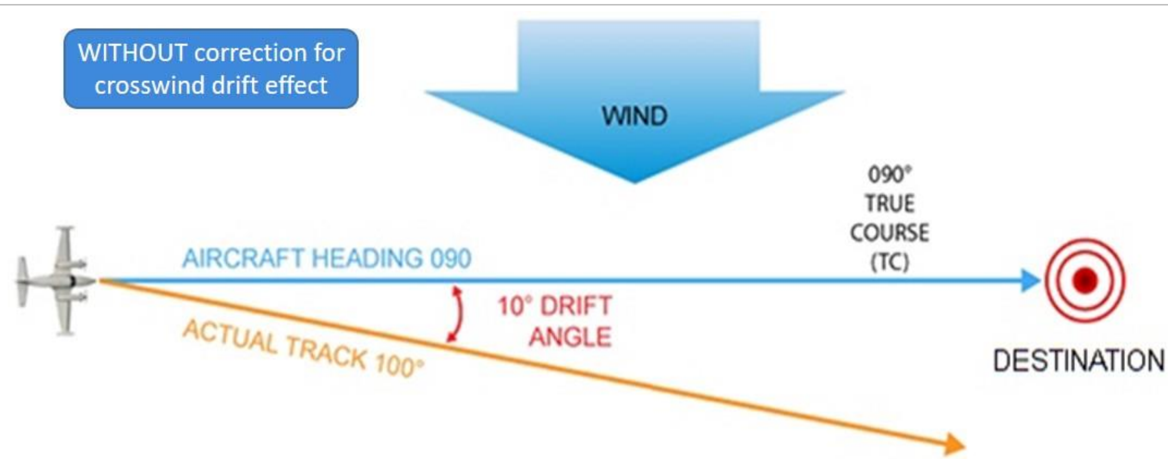
Track is the actual path that the aircraft has flown over the Earth's surface.

True Heading

True Heading is True Course corrected for the wind correction angle (TH = TC+/-WCA).

Without compensation for wind:

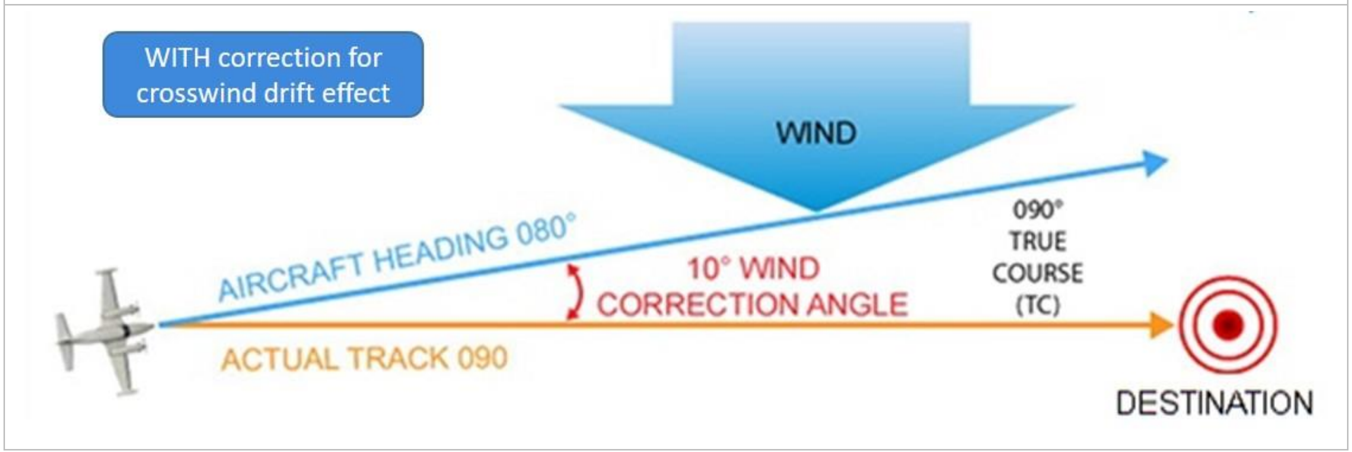
- The pilot attempts to fly TC
- The wind pushes aircraft off course
- The track over ground is not desired one
- The difference is called **drift angle**



To compensate for wind, pilots correct heading toward direction from which wind is coming:

- Right or left of TC
- The resulting angle is WCA
- The resulting heading is called the TH

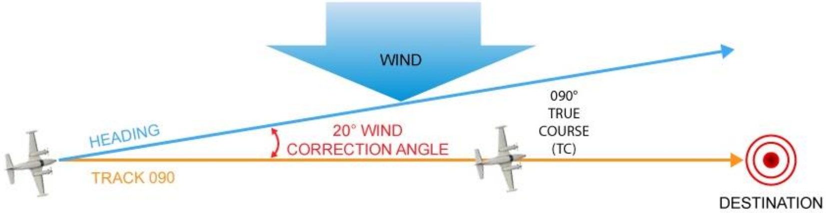
It is the controller's responsibility to compensate for wind speed and direction when formulating estimates and issuing radar vectors.



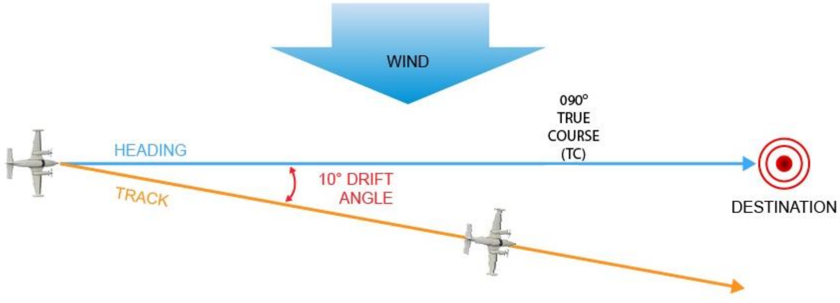
Knowledge Check D

REVIEW what you have learned so far about factors affecting navigation. ANSWER the questions listed below.

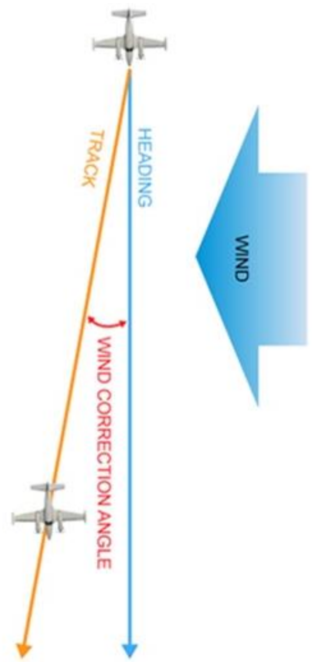
1. If the Wind Correction Angle is 20° and the true course is 090°, what is the **true heading** of the aircraft? *(Review the image and select the correct answer.)*
   - ❑ 080°
   - ❑ 120°
   - ❑ **070**°



2. If the desired true course of the aircraft is 90° and the drift angle is 10°, what is the **track** of the aircraft? *(Review the image and select the correct answer.)*
   - ❑ 090°
   - ❑ **100**°
   - ❑ 080°



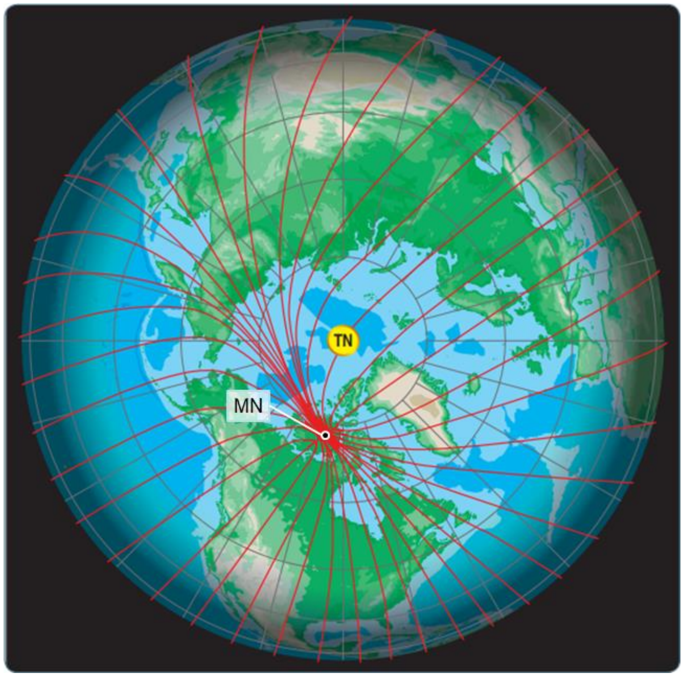
3. If the track of the aircraft is 195° and the aircraft heading is 180°, what is the wind correction angle in degrees? *(Review the image and select the correct answer.)*
   - ❑ **<u>015°</u>**
   - ❑ 020°
   - ❑ 010°



Magnetic Variation

Variation is the angular difference between true north (TN) and magnetic north (MN).

- Variation is measured in degrees from true north
- The magnetic north pole is located 1,300 miles from the true north pole and is always moving
- Isogonic lines connect points of equal difference between true and magnetic north
  - Agonic line connects points of zero variation
  - There is only one agonic line



Application

- Magnetic Heading (MH) is TH corrected for variation (TH ± VAR = MH)
- Magnetic directions are used in pilot and controller communications

Example: “FLY HEADING TWO FOUR ZERO.” “TURN RIGHT HEADING ONE TWO FIVE.”

Exception: Wind in weather reports and forecasts is given in reference to true north.

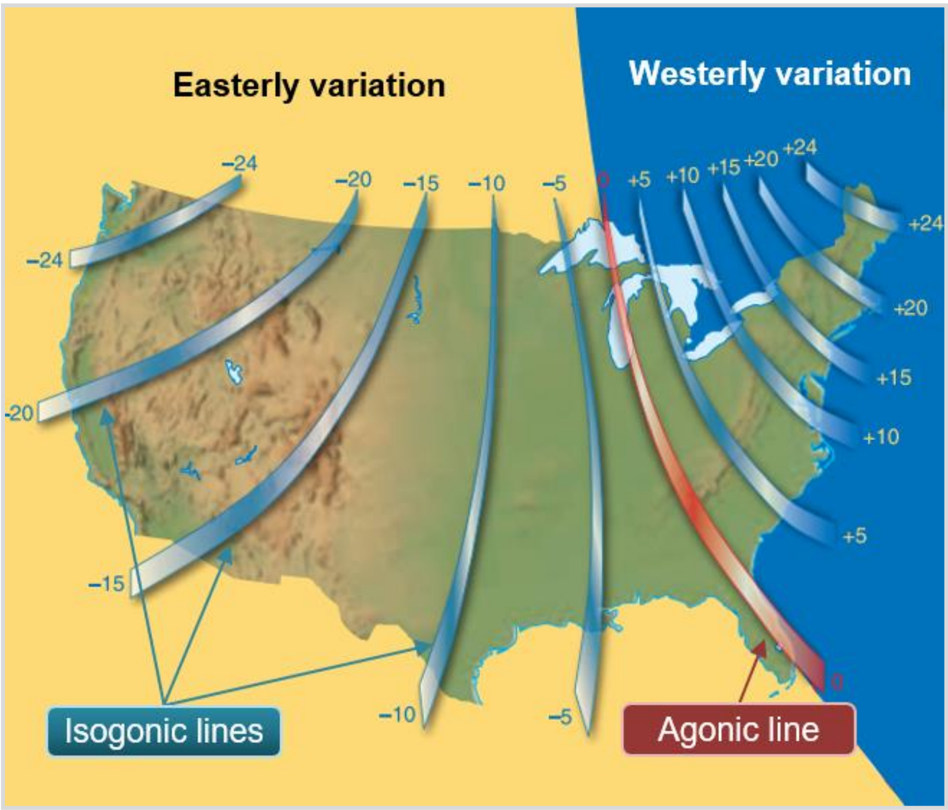
Isogonic lines

East/west variation, correction is necessary.

- For east variation, subtract degrees of variation
- For west variation, add degrees of variation

Agonic line

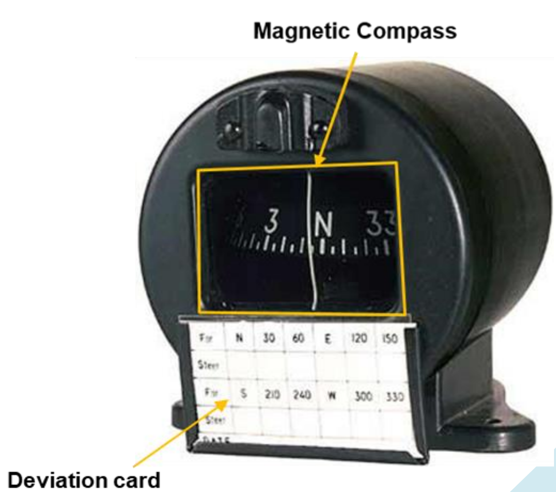
Zero variation, no correction necessary.



Magnetic Deviation

Magnetic deviation (DEV) is the error of a magnetic compass due to magnetic influence in the structure and equipment of the aircraft.

Magnetic compass error may change as the aircraft heading changes.



- Results from magnetic influences within aircraft:
  - Electrical circuits
  - Engine
  - Other magnetized parts
- Deviation card is mounted near the compass
  - Lists corrections
- Compass Heading (CH) is the MH corrected for deviation (MH $\pm$ DEV = CH)

Knowledge Check E

REVIEW what you have learned so far about factors affecting navigation. ANSWER the questions listed below.

1. Which line connects points of equal difference between true and magnetic north? *(Select the correct answer.)*
   - ❑ Agonic
   - ❑ Deviation
   - ❑ **Isogonic**

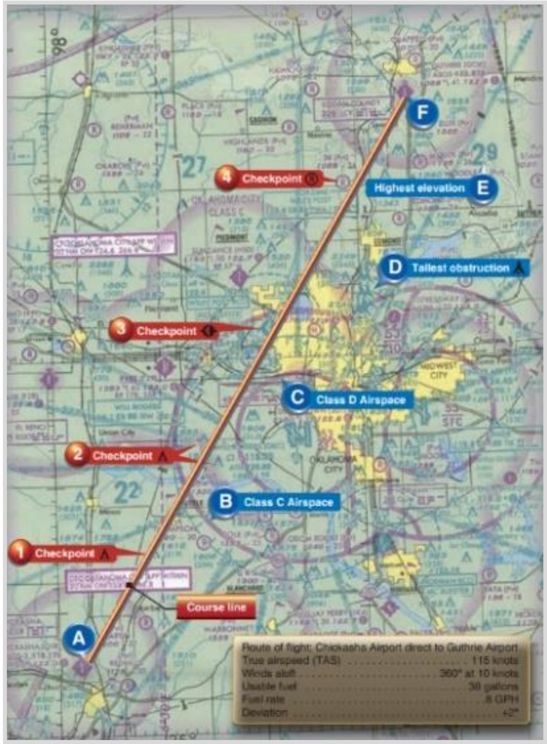
2. A line with zero variation where no correction is necessary is called a(n) _____ line. *(Select the correct answer.)*
   - ❑ **Agonic**
   - ❑ Magnetic
   - ❑ Isogonic

3. What term denotes a magnetic compass error that is caused by materials that possess magnetic properties within the aircraft? *(Select the correct answer.)*
   - ❑ **Deviation**
   - ❑ Variation
   - ❑ Interference

4. True heading is true course corrected for effects of _____. *(Select the correct answer.)*
   - ❑ Magnetic variation
   - ❑ Compass error
   - ❑ **Wind**

Basic Navigation Methods

There are two basic navigation methods: dead reckoning and pilotage



Dead Reckoning

Dead Reckoning is navigation of an airplane solely by means of computations based on airspeed, course, heading, wind direction, speed, GS, and elapsed time.

- Dead reckoning is the basic method of navigation used for flying a predetermined course taking into account the effects of wind on:
  - Track
  - GS
- Apply wind correction to true course to determine:
  - TH
  - GS
- Using the appropriate corrections, pilots can estimate how long to fly on certain headings to arrive over their destination
  - This can be done with or without reference to the ground

In flight planning, aviation charts are used to plot and determine the following:

- True course
- Distance
- Variation

Pilot’s Planning Sheet

- True course (TC) 031 degrees
- Wind correction angle (WCA) is determined to be 3 degrees
- True heading (TH) 028 degrees
- Magnetic variation (MAG VAR) 7 degrees east
- Magnetic heading (MH) 021 degrees
- Equipment deviation (DEV) +2 degrees
- Compass heading (CH) 023 degrees

PILOT'S PLANNING SHEET

PLANE IDENTIFICATION N123DB DATE

COURSE	TC	WIND Knots	WIND From	ALTITUDE	WCA R+ L-	TH	MAG VAR W+ E-	MH	DEV	CH	TOTAL MILES	GS	TOTAL TIME	FUEL RATE	TOTAL FUEL
From Chickasha / To Guthrie	031°	10	360°	8000	3° L	28	7° E	21°	+2°	23	53	106 kts	35 min	8 GPH	38 gal
From / To															

Pilotage

Pilotage is the determination of position by identification of landmarks from their representation on a chart. Pilotage is a technique used by pilots to navigate by visual reference to landmarks.

The pilot draws a course line on the chart from selected checkpoints and prominent landmarks.

- Pilot flies from landmark to landmark by visual references
  - Used in VFR conditions only
- It is suitable for slow aircraft flying close to the ground

Knowledge Check F

REVIEW what you have learned so far about factors affecting navigation. ANSWER the questions listed below.

1. What method of navigation requires flying a predetermined course while taking into account the effects of wind? *(Select the correct answer.)*
   - ❑ **Dead reckoning**
   - ❑ Pilotage
   - ❑ Radio navigation

2. Navigation by reference to visible landmarks is called _____. *(Select the correct answer.)*
   - ❑ Dead reckoning
   - ❑ **Pilotage**
   - ❑ Radio navigation

Factors Affecting Navigation Summary

There are a multitude of factors that affect navigation. Wind, magnetic deviation and variation can cause an aircraft to veer off course.

SUMMARY

The purpose of this module was to introduce the basics of navigation; the methods of navigation used by a pilot; and times, speeds, distances, and other factors associated with basic navigation.

In accordance with FAA-H-8083-25 Pilot's Handbook of Aeronautical Knowledge; FAA-H-8083-15, Instrument Flying Handbook; Aeronautical Information Manual (AIM); and FAA Order JO 7110.65, Air Traffic Control; you should now be able to:

- Identify reference lines of the Earth and their purpose
- Identify coordinates and measurements used in navigation
- Identify methods of conversion for time, speed, and distance
- Identify types of speed
- Identify effects of altitude and temperature on speed
- Identify methods of calculating time, speed, and distance
- Identify effects of wind on flight
- Identify magnetic variations and deviations
- Identify basic navigation methods

FACILITATOR INSTRUCTIONS	DELIVERY METHOD
■ Navigate to the ***Factors Affecting Navigation*** lesson and facilitate a brief discussion of the lesson content ■ Navigate to the ***Parking Lot*** link within Blackboard and review any student questions ■ Address ***Parking Lot*** questions and facilitate a brief discussion of the lesson content ■ Instruct students to prepare for the End-of-Module test by putting away their Student Guides	Facilitated Discussion **EST. RUN TIME** 30 mins.

FACILITATOR INSTRUCTIONS	DELIVERY METHOD
■ **ENABLE *Basic Navigation End-of-Module Test*** link in Blackboard ■ Instruct students: ○ Clear desks ○ Do not write anything during or after the test ○ Navigate to the ***Basic Navigation End-of-Module Test*** link in Blackboard ○ Once they are satisfied with their responses, click “Save and Submit;” do not click “OK” to review results until directed to do so ○ Choose “Cancel” if they receive a warning message that the test has unanswered questions; choosing OK will submit the test and not allow them to go back and answer the questions ○ Leave the room after submitting the test and return at the “Be Back” time ■ ***Note:*** *This test is scored but not graded* ■ During test, monitor students to ensure a secure testing environment ■ Identify the most commonly missed questions by reviewing student statistics in Blackboard ■ Instruct students to click “View Results” when ready to review commonly missed questions ■ Review commonly missed questions with students	Blackboard Assessment **EST. RUN TIME** 30 mins.

END-OF-MODULE TEST (ANSWER KEY)

Note: *Test questions in Blackboard are presented to the students in random order. Please be aware the test key question order will not match the student version.*

1. The _________ is an imaginary circle equidistant from the poles of the Earth. *(Select the correct answer.)*
   - ❑ **Equator**
   - ❑ Prime Meridian
   - ❑ International dateline
   - ❑ Parallels of latitude

   Reference(s): FAA-H-8083-25, Chap. 16

2. Parallels and meridians are divided into ______, minutes, and seconds. *(Select the correct answer.)*
   - ❑ **Degrees**
   - ❑ Circles
   - ❑ Days
   - ❑ Hours

   Reference(s): FAA-H-8083-25, Chap. 16

3. How do you convert local Daylight Savings Time to UTC? *(Select the correct answer.)*
   - ❑ **Add the conversion factor, then subtract 1 hour**
   - ❑ Subtract the conversion factor
   - ❑ Subtract the conversion factor, then add 1 hour
   - ❑ Add the conversion factor, then add 1 hour

   Reference(s): FAA-H-8083-25, Chap. 16

4. How many statute miles would 100 nautical miles equal? *(Select the correct answer.)*
   - ❑ **115**
   - ❑ 130
   - ❑ 95
   - ❑ 87

   Reference(s): FAA-H-8083-25, Chap. 16

5. What is the width of each time zone established around the Earth? *(Select the correct answer.)*
   - ❑ **15º of longitude**
   - ❑ 15’ of longitude
   - ❑ 15º of latitude
   - ❑ 15’ of latitude

   Reference(s): FAA-H-8083-25, Chap. 16

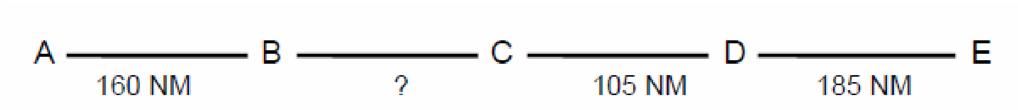
6. Which type of speed is expressed as a decimal and represents a ratio of true airspeed to the speed of sound? *(Select the correct answer.)*
   - ❑ **MACH**
   - ❑ IAS
   - ❑ TAS
   - ❑ GS

   Reference(s): JO 7110.65, Pilot/Controller Glossary

7. What effect does an increase in temperature and/or altitude have on the indicated airspeed of an aircraft? *(Select the correct answer.)*
   - ❑ **An increase in temperature or altitude will have the same effect on indicated airspeed because the air becomes less dense in both cases**
   - ❑ An increase in temperature will have no impact on the indicated airspeed of an aircraft since air density remains the same
   - ❑ An increase in the altitude of an aircraft increases the indicated airspeed because air density increases with altitude
   - ❑ An increase in altitude will significantly reduce indicated airspeed because the air becomes more dense the higher the altitude

   Reference(s): FAA-H-8083-25, Chap. 16

8. King Air 2425K departed “A” at 2228 UTC. With a consistent 180 knot GS, N2425K arrived at destination “E” at 0258 UTC. How long did it take the aircraft to cover the distance from “B” to “C?” *(Select the correct answer.)*
   - ❑ **2 hours**
   - ❑ 1.5 hours
   - ❑ 1.75 hours
   - ❑ 2.25 hours



   Reference(s): FAA-H-8083-25, Chap. 16

9. How would you designate 2 PM on a 24-hour clock? *(Select the correct answer.)*
   - ❑ **1400**
   - ❑ 1200
   - ❑ 0200
   - ❑ 2200

   Reference(s): FAA-H-8083-25, Chap. 16

10. An aircraft encounters a 20 knot crosswind and makes **NO** heading correction. After 1 hour of flight, how far off course would the aircraft be? *(Select the correct answer.)*
    - ❑ **<u>20 NM</u>**
    - ❑ 10 NM
    - ❑ 10 SM
    - ❑ 20 SM

    Reference(s): FAA-H 8083-25, Chap. 16

11. What should a pilot keep in mind when maneuvering an aircraft during a crosswind? *(Select the correct answer.)*
    - ❑ **<u>Affects the speed and direction of flight</u>**
    - ❑ Increases the tailwind and affects true airspeed
    - ❑ Reduces the headwind and increases true airspeed
    - ❑ Increases the speed and reduces the tailwind

    Reference(s): FAA-H 8083-25, Chap. 16

12. What term denotes a magnetic compass error that is caused by materials that hold magnetic properties within the aircraft? *(Select the correct answer.)*
    - ❑ **<u>Deviation</u>**
    - ❑ Variation
    - ❑ Isogonic line
    - ❑ Pilotage

    Reference(s): FAA-H 8083-25, Chap. 16

13. What form of basic navigation uses a predetermined course and is navigated using a compass? *(Select the correct answer.)*
    - ❑ **<u>Dead reckoning</u>**
    - ❑ Pilot planning
    - ❑ Pilotage
    - ❑ Satellite navigation

    Reference(s): FAA-H 8083-25, Chap. 16; AIM; Pilot/Controller Glossary