OKLAHOMA Aeronautics

TOOLKIT 0
GETTING AIRBORNE WITH NUMBERS

OKLAHOMA CareerTech

Overview: Students practice using the 24-hour clock and making basic calculations such as the time required for a flight, average groundspeed and fuel consumption.
Source: *Fostering Aviation Activities: Junior High Level,* FAA
Grade Levels: 6-8, 9-12
Location: All resources are provided in this toolkit.

1 Student Activity	2 Lesson Plan or Procedure	3 Activity Evaluation or Rubric	4 Suggested Activities	5 Glossary	6 Teacher Background or Concepts	7 Student Background or Concepts	8 Standards Alignment
x		x					
Notes:							

KEY:

1. Student Activity: This is the focus of the toolkit. It is at least one complete activity or lab for students to complete that relates to a topic relevant to aviation/aerospace. It may include related worksheets.

2. Lesson Plan or Procedure: These are the steps or instructions for the teacher to use to deliver the activity.

3. Activity Evaluation or Rubric: These are the answers to the activity or a rubric or other tool for evaluating students' results.

4. Suggested Activities: These are additional or extension strategies for the teacher that relate to the topic/activity.

5. Glossary: This is a list of the vocabulary terms and their definitions that relate to the activity and/or associated concepts.

6. Teacher Background or Concepts: This is any background information for the teacher that explains key concepts relating to the topic/activity, provides the aerospace context for the activity or otherwise helps prepare the teacher for the topic/activity.

7. Student Background or Concepts: This is any background information for the student about theory and concepts related to the topic/activity. It may be separate handout files or a text section within the larger topic/activity.

8. Standards Alignment: These are education or industry standards that align with the topic/activity.

SUPPLEMENTAL RESOURCES

General Resources

• *Pilot's Handbook of Aeronautical Knowledge,* Federal Aviation Administration, 2016. Free to download at https://www.faa.gov/regulations_policies/handbooks_manuals/aviation/.

• Airport Acronyms and Abbreviations, Federal Aviation Administration, https://www.faa.gov/airports/resources/acronyms/

• Find an Airport, Oklahoma Aeronautics Commission, https://oac.ok.gov/airports

• K-12 Student/Teacher Resources, NASA, https://www.nasa.gov/aeroresearch/resources/k-12-resources

• *"Science Takes Flight With Paper Airplanes,"* Edutopia, https://www.edutopia.org/article/science-takes-flight-paper-airplanes

Instructional Practice Resources

• *60 Formative Assessment Strategies*, Natalie Regier, 2012. Free to download at https://www.okcareertech.org/educators/resource-center/teacher-trainer-tools.

• *Student Learning That Works: How brain science informs a student learning model,* McREL International, 2018. Free to download at https://www.mcrel.org/student-learning-that-works-wp/.

Career Planning Resources

• *OK Career Guide.* Free to Oklahoma educators. For more information, see https://www.okcareertech.org/educators/career-and-academic-connections/ok-career-guide.

• Aviation Organizations, Oklahoma Aeronautics Commission, https://oac.ok.gov/media-outreach/aviation-organizations

• *Careers in Aerospace,* American Institute of Aeronautics and Astronautics. Free to download at https://www.aiaa.org/get-involved/students-educators/Careers-in-Aerospace.

• *Flying for a Career,* AOPA, https://www.aopa.org/training-and-safety/learn-to-fly/flying-for-a-career

• *Oklahoma Aerospace: Building on a Rich Tradition,* Oklahoma Department of Career and Technology Education, https://www.okcareertech.org/business-and-industry/aerospace-and-aviation

Activity-Specific Resources

• *Fostering Aviation Activities: Junior High Level,* FAA, https://www.faa.gov/education/educators/curriculum/k12/

TEACHER BACKGROUND INFORMATION: TIME IN AVIATION

The clock is one of the most useful flight instruments. It is used for figuring important items such as the time required for a flight, the average ground speed and fuel consumption. These are more crucial in aviation than in ground transportation.

Time Zones

A day is defined as the time required for the Earth to make one complete rotation of 360 degrees. Since the day is divided into 24 hours, the Earth revolves at the rate of 15 degrees an hour. Noon is the time when the sun is directly above a meridian; to the west of that meridian is morning, and to the east is afternoon.

The standard practice is to establish a time zone for each 15 degrees of longitude. This makes a difference of exactly 1 hour between each zone. In the conterminous United States, there are four time zones. The time zones are Eastern (75 degrees), Central (90 degrees), Mountain (105 degrees) and Pacific (120 degrees). The dividing lines are somewhat irregular because communities near the boundaries often find it more convenient to use time designations of neighboring communities or trade centers.

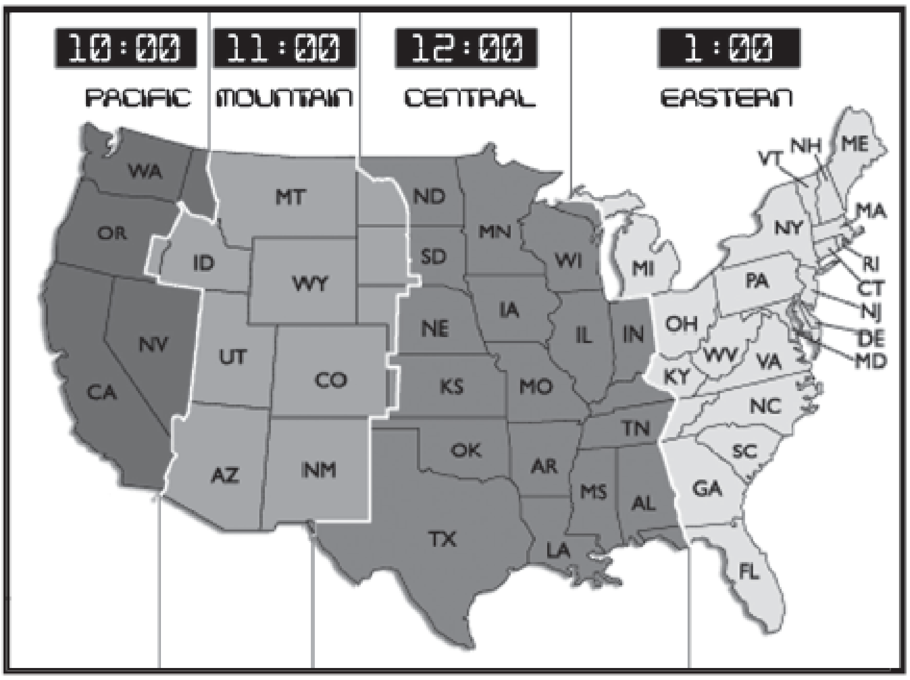
These time zone differences must be taken into account during long flights eastward, especially if the flight must be completed before dark. Remember, an hour is lost when flying eastward from one time zone to another or perhaps even when flying from the western edge to the eastern edge of the same time zone. Determine the time of sunset at the destination by consulting the flight service station and take this into account when planning an eastbound flight.

The world is divided into 25 time zones. All clocks within each time zone tell the same time.

• All time zones are based on the time in Greenwich, England. This is the point where the meridian is 0 degrees longitude. (The world is divided into sections by imaginary lines called longitude and latitude. Longitudinal lines — also called meridians — run north to south, and latitudinal lines run east to west.)

• The system of time is called the Greenwich Mean Time or Coordinated Universal Time, abbreviated UTC. Each time zone is usually identified in terms of UTC, although GMT is also used. For example, the time zone in Paris, France is UTC+1 (one hour ahead or later than UTC), and the time zone in Los Angeles, California is UTC-8 (8 hours behind or earlier than UTC).
    • As you travel west of Greenwich, England, you lose one hour for each time zone you cross (UTC-1).
    • As you travel east of Greenwich, England, you gain one hour for each time zone you cross (UTC+1).

• The International Date Line is a meridian located in the Pacific Ocean at 180 degrees longitude. As you cross this line, the date changes and you either lose or gain one day. The western side of the line is one day ahead of the eastern side of the line.



24-Hour Clock

The 24 hours of a day start at 0 (midnight) and end at 23 (11 p.m.). This system of measuring the hours in a day is used in most countries outside the United States. In the United States, this system is often called military time.

In most aviation operations, time is expressed in terms of the 24-hour clock. Air traffic control instructions, weather reports and broadcasts and estimated times of arrival are all based on this system.

TEACHER BACKGROUND INFORMATION: BASIC CALCULATIONS

Before a cross-country flight, a pilot should make common calculations for time, speed, distance and the amount of fuel required.

Converting Minutes to Equivalent Hours

Frequently, it is necessary to convert minutes into equivalent hours when solving speed, time and distance problems. To convert minutes to hours, divide by 60 (60 minutes = 1 hour). Thus, 30 minutes is 30/60 = 0.5 hour. To convert hours to minutes, multiply by 60. Thus, 0.75 hour equals 0.75 × 60 = 45 minutes.

Time T = D/GS
To find the time (T) in flight, divide the distance (D) by the GS (groundspeed). The time to fly 210 NM (nautical miles) at a GS of 140 knots is 210 ÷ 140 or 1.5 hours. (The 0.5 hour multiplied by 60 minutes equals 30 minutes.) Answer: 1:30.

Note: A nautical mile is based on the circumference of the earth and is equal to one minute of latitude. It is slightly more than a statute (land measured) mile (1 nautical mile = 1.1508 statute miles). Nautical miles are used for charting and navigating. (Source: NOAA)

Distance D = GS X T
To find the distance flown in a given time, multiply GS by time. The distance flown in 1 hour 45 minutes at a GS of 120 knots is 120 × 1.75 or 210 NM.

Groundspeed GS = D/T
To find the GS, divide the distance flown by the time required. If an aircraft flies 270 NM in 3 hours, the GS is 270 ÷ 3 = 90 knots.

Converting Knots to Miles Per Hour

Another conversion is that of changing knots to miles per hour. The aviation industry uses knots more frequently than miles per hour, but it is important to understand the conversion for those who use miles per hour when working with speed problems. The National Weather Service reports both surface winds and winds aloft in knots. However, airspeed indicators in some aircraft are calibrated in miles per hour (although many are now calibrated in both miles per hour and knots). Pilots, therefore, should learn to convert wind speeds that are reported in knots to miles per hour.

A knot is 1 nautical mile per hour. Because there are 6,076.1 feet in 1 nautical mile and 5,280 feet in 1 statute mile (the miles shown on road signs and maps), the conversion factor is 1.15.

To convert knots to miles per hour, multiply speed in knots by 1.15. For example, a wind speed of 20 knots is equivalent to 23 mph.

Most flight computers or electronic calculators have a means of making this conversion. Another quick method of conversion is to use the scales of nautical miles and statute miles at the bottom of aeronautical charts.

Fuel Consumption

To ensure that sufficient fuel is available for an intended flight, the pilot must be able to accurately compute aircraft fuel consumption during preflight planning.

> Typically, fuel consumption in gasoline-fueled aircraft is measured in gallons per hour. Since turbine engines consume much more fuel than reciprocating engines, turbine-powered aircraft require much more fuel and thus much larger fuel tanks.
>
> When determining these large fuel quantities, using a volume measurement such as gallons presents a problem. This is because the volume of fuel varies greatly in relation to temperature. In contrast, density (weight) is less affected by temperature and therefore, provides a more uniform and repeatable measurement. For this reason, jet fuel is generally quantified by its density and volume.

This standard industry convention yields a pounds-of-fuel-per-hour value which, when divided into the nautical miles per hour of travel value, results in a specific range value. The typical label for specific range is NM per pound of fuel, or often NM per 1,000 pounds of fuel.

When planning a flight, the pilot must determine how much fuel is needed to reach the destination. To do this, the pilot calculates the distance the aircraft can travel (with winds considered) at a known rate of fuel consumption (gal/hr or lbs/hr) for the expected groundspeed and ensures this amount plus an adequate reserve is available on board. Groundspeed determines the time the flight will take. The amount of fuel needed for a given flight can be calculated by multiplying the estimated flight time by the rate of consumption.

> For example, a flight of 400 NM at 100 knots GS takes 4 hours to complete. If an aircraft consumes 5 gallons of fuel per hour, the total fuel consumption is 20 gallons (4 hours times 5 gallons). In this example, there is no wind; therefore, true airspeed is also 100 knots, the same as GS.

Source: Adapted from *Pilot's Handbook of Aeronautical Knowledge* (2016), FAA

THE 24-HOUR CLOCK

12-HOUR CLOCK	24-HOUR CLOCK
12:00 a.m. (midnight)	0000 hours
1:00 a.m.	0100 hours
2:00 a.m.	0200 hours
3:00 a.m.	0300 hours
4:00 a.m.	0400 hours
5:00 a.m.	0500 hours
6:00 a.m.	0600 hours
7:00 a.m.	0700 hours
8:00 a.m.	0800 hours
9:00 a.m.	0900 hours
10:00 a.m.	1000 hours
11:00 a.m.	1100 hours
12:00 p.m. (noon)	1200 hours
1:00 p.m.	1300 hours
2:00 p.m.	1400 hours
3:00 p.m.	1500 hours
4:00 p.m.	1600 hours
5:00 p.m.	1700 hours
6:00 p.m.	1800 hours
7:00 p.m.	1900 hours
8:00 p.m.	2000 hours
9:00 p.m.	2100 hours
10:00 p.m.	2200 hours
11:00 p.m.	2300 hours

USING THE 24-HOUR CLOCK

Name:____ Date:_________________

Instructions

• Complete the problems using the 12-hour clock and the 24-hour clock (military time).

Change the standard time to military time:

1.	1:40 p.m.	=	_____ hours
2.	5:16 p.m.	=	_____ hours
3.	7:39 p.m.	=	_____ hours
4.	6:47 p.m.	=	_____ hours
5.	8:35 p.m.	=	_____ hours
6.	12:30 p.m.	=	_____ hours
7.	11:49 p.m.	=	_____ hours
8.	2:32 p.m.	=	_____ hours
9.	12:20 p.m.	=	_____ hours
10.	11:43 p.m.	=	_____ hours

Change the military time to standard time (circle a.m. or p.m. as appropriate):

1.	0430 hours	=	_____ a.m./p.m.
2.	1619 hours	=	_____ a.m./p.m.
3.	0003 hours	=	_____ a.m./p.m.
4.	1317 hours	=	_____ a.m./p.m.
5.	2148 hours	=	_____ a.m./p.m.
6.	2041 hours	=	_____ a.m./p.m.
7.	1022 hours	=	_____ a.m./p.m.
8.	2347 hours	=	_____ a.m./p.m.
9.	0103 hours	=	_____ a.m./p.m.
10.	1508 hours	=	_____ a.m./p.m.

CALCULATING THE TIME REQUIRED FOR A FLIGHT

Name:____ Date:__________________

Instructions

• Calculate the time required to make the flight based on the given distance and average groundspeed.

Example: What will be the length of a flight of 329 NM at an average speed of 94 knots?

Solution: Divide 329 by 94.

329/94 = 3.5 hours = 3 HRS 30 MIN.

	Distance (NM)	Average Groundspeed (knots)	Time
1	275 NM	110	
2	180 NM	45	
3	585 NM	130	
4	2475 NM	275	
5	1875 NM	600	
6	195 NM	65	
7	230 NM	100	
8	280 NM	120	

9. What is the length of a flight of 450 NM at an average speed of 90 knots?

10. A plane flies 370 NM at an average groundspeed of 95 knots. What time is required for the flight?

CALCULATING AVERAGE GROUNDSPEED

Name:____ Date:____________

Instructions

- Calculate the average groundspeed in both knots and miles per hour.
- Round to the nearest knot or mph.

To find the groundspeed, divide the distance flown by the time required. If an aircraft flies 270 NM in 3 hours, the GS is 270 ÷ 3 = 90 knots.

To convert knots to mph, multiply speed in knots by 1.15.

	Distance (NM)	Average Groundspeed (knots)	Average Groundspeed (mph)	Time
1	285			3 HRS
2	780			6 1/2 HRS
3	800			5 1/3 HRS
4	1260			4 HRS 40 MIN
5	2875			6 HRS 15 MIN
6	675			4 1/2 HRS
7	594			3 HRS 18 MIN
8	245			2 HRS 27 MIN

9. What is the groundspeed for a flight of 595 NM in 3 ½ hours? Calculate the GS in knots and mph.

10. An aircraft flies 1104 NM in 4 hours, 36 minutes. What is the average GS in knots and mph?

CALCULATING FUEL CONSUMPTION

Name:____ Date:________________

Instructions

- Calculate the amount of fuel to be used. Assume there is no wind.
- Round up to the nearest whole gallon.

Example: A flight of 400 NM at 100 knots GS takes 4 hours to complete. If an aircraft consumes 5 gallons of fuel per hour, the total fuel consumption is 20 gallons (4 hours times 5 gallons). In this example, there is no wind.

Without a fuel reserve:

	Flying Time	Fuel Consumption (Gallons per Hour)	Amount of Fuel To Be Used
1	3 HRS 30 MIN (3.5)	6 GPH	
2	5 HRS 20 MIN (5.33)	12 GPH	
3	4 ½ HRS (4.5)	5 GPH	
4	4 HRS 22 ½ MIN (4.375)	20 GPH	
5	6 HRS 10 MIN (6.17)	40 GPH	
6	2 HRS 24 MIN (2.4)	5 GPH	
7	3 HRS 12 MIN (3.2)	15 GPH	
8	5 HRS 5 MIN (5.08)	18 GPH	

9. How much gasoline will be consumed in a flight of three hours, forty minutes if the engine uses nine gallons per hour?

10. An aircraft makes a flight of six hours, forty-two minutes. The engine uses an average of 18 gallons of gasoline per hour. How much gasoline will be consumed during the flight?

With a Fuel Reserve

	Flying Time	Fuel Consumption (Gallons per Hour)	Amount of Fuel Needed with 25% Reserve
1	3 HRS 40 MIN	9 GPH	
2	2 HRS 30 MIN	8 GPH	
3	2 HRS 24 MIN	5 GPH	
4	4 HRS 20 MIN	12 GPH	
5	6 HRS 50 MIN	24 GPH	

ANSWERS TO ACTIVITIES

Using the 24-Hour Clock

Change the standard time to military time:

1. 0140 hours
2. 1716 hours
3. 1939 hours
4. 1874 hours
5. 2035 hours
6. 1230 hours
7. 2349 hours
8. 1432 hours
9. 1220 hours
10. 2343 hours

Change the military time to standard time:

1. 4:30 a.m.
2. 4:19 p.m.
3. 12:03 a.m.
4. 1:17 p.m.
5. 9:48 p.m.
6. 8:41 p.m.
7. 10:22 a.m.
8. 11:47 p.m.
9. 1:03 a.m.
10. 3:08 p.m.

Calculating the Time Required for a Flight

1. 2.5 = 2 HRS 30 MIN
2. 4 HRS
3. 4.5 = 4 HRS 30 MIN
4. 9 HRS
5. 3.125 = 3 HRS 7 ½ MIN
6. 3 HRS
7. 2.3 = 2 HRS 18 MIN
8. 2.33 = 2 HRS 20 MIN
9. 5 HRS
10. 3.9 = 3 HRS 54 MIN

Calculating Average Groundspeed

1. 95 knots, 109 mph
2. 120 knots, 138 mph
3. 150 knots, 173 mph
4. 270 knots, 311 mph
5. 460 knots, 529 mph
6. 150 knots, 173 mph
7. 180 knots, 207 mph
8. 100 knots, 115 mph
9. 170 knots, 196 mph
10. 240 knots, 276 mph

Calculating Fuel Consumption

With no fuel reserve:

1. 21 gallons
2. 64 gallons
3. 23 gallons
4. 88 gallons
5. 247 gallons
6. 12 gallons
7. 48 gallons
8. 92 gallons
9. 33 gallons
10. 121 gallons

With a fuel reserve (25%):

1. 44 gallons (43.92)
2. 27 gallons (26.6)
3. 16 gallons
4. 70 gallons (69.28)
5. 219 gallons (218.56)

TEACHER ACTIVITY REFLECTION WORKSHEET

• What instructional objectives were met? How do I know?

• Were students actively engaged? How do I know?

• Did I alter my instructional plan? How and why?

• What formative assessment(s) did I use?

• What would I do differently the next time?

• What additional resources and/or support would enhance this activity?