OKLAHOMA Aeronautics

TOOLKIT 4

BUILD YOUR OWN WEATHER STATION

OKLAHOMA CareerTech

Overview: Students build six instruments they can use to make scientific measurements of their local weather.
Source: *Discover Your World with NOAA* activity book, National Oceanic and Atmospheric Administration
Grade Levels: 6-8, 9-12
Location: https://oceanservice.noaa.gov/education/discoveryourworld.html

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							
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
- *Aeronautics Educator Guide*, NASA, https://www.nasa.gov/stem-ed-resources/aeronautics.html

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

- *Aviation Weather*, FAA, https://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentid/1029851
- Cloudwise and Weatherwise posters, NOAA, https://www.weather.gov/jetstream/noaawise
- Tornadoes, Lightning, and Rainbows! 25 Activities for Teaching Weather, We Are Teachers, https://www.weareteachers.com/best-weather-activities/
- Weather Experiments, National Weather Center, https://www.ou.edu/nwc/learn/experiments
- Weather Experiments, National Weather Service, https://www.weather.gov/bmx/kidscorner_weatherexperiments
- Weather Experiments, Weather Wiz Kids, https://www.weatherwizkids.com/weather-experiments.htm

TEACHER BACKGROUND INFORMATION
INGREDIENTS OF WEATHER

Weather is the state of the atmosphere at a given time and place, with respect to variables such as the following:

- Temperature (heat or cold).
- Moisture (wetness or dryness).
- Wind velocity (calm or storm).
- Visibility (clearness or cloudiness).
- Barometric pressure (high or low).

The **atmosphere** is a blanket of air made up of a mixture of gases that surrounds the earth. It reaches almost 350 miles above the surface of the Earth. This mixture is in constant motion. If the atmosphere were visible, it might look like an ocean with swirls and eddies, rising and falling air and waves that travel for great distances. Life on Earth is supported by the atmosphere, solar energy and the planet's magnetic fields. The atmosphere absorbs energy from the sun, recycles water and other chemicals and works with the electrical and magnetic forces to provide a moderate climate. The atmosphere also protects life on Earth from high energy radiation and the frigid vacuum of space.

In any given volume of air, nitrogen accounts for 78% of the gases that make up the atmosphere and oxygen makes up 21%. Argon, carbon dioxide and traces of other gases make up the remaining 1%.

The atmosphere has four separate layers or spheres. The **troposphere** reaches from sea level to 20,000 feet. This is the layer where most weather, clouds, storms and temperature changes take place. Above the troposphere is the *stratosphere*, which extends to about 160,000 feet. Not much weather exists in this layer. The *mesosphere* and the *thermosphere* are the two highest layers. They have little impact on the weather.

Most weather happens in the troposphere, the lowest layer of the atmosphere. Three factors are the key causes of weather:

- Air temperature.
- Air pressure.
- Humidity.

Air temperature measures the energy of motion of the gas molecules in the air. Radiation from the sun and radiation from the Earth both contribute to heating and cooling the atmosphere.

The sun constantly sends radiation into space. Visible light is one kind of this radiation from the sun. The other kinds of radiation are invisible to people; they include infrared (heat) rays and ultraviolet rays. Clouds help to reflect about 30% of the radiation from the sun that reaches the atmosphere back into space. The rest — about 70% — is absorbed by the atmosphere and by the surface of the Earth, making them warmer.

The Earth, warmed by the radiation from the sun, cools down by sending out infrared (heat) rays. Most of this radiation is absorbed by the atmosphere (the rest goes into space). This is called the *greenhouse effect*. It makes the air that is closer to the Earth's surface almost 60 degrees Fahrenheit warmer than it would otherwise be.

The atmosphere, warmed by the radiation from the sun, also gets rid of this heat energy by sending out infrared rays. These rays from the atmosphere travel to the surface of the Earth and out into space.

The air temperature changes for many reasons. The air temperature is usually warmer in the daytime because that is when the Earth receives the radiation from the sun. The air temperature drops at night when the Earth sends out infrared rays into space. As the seasons change, the air temperature also changes — except near the equator, where the temperature remains almost the same all year. Everywhere else, summers are warm and winters are cold. The sun is higher in the sky during the summer, making the days longer. The intensity of the sunlight is also greater. This leads to more heating from the sun. The altitude also affects the temperature of the air. The air temperature in the troposphere drops about 3.5 degrees Fahrenheit for every 1,000 feet of elevation. This explains why it is colder the higher you climb or hike.

Air pressure is the weight per unit of area of a column of air. This column of air stretches to the top of the atmosphere. The air pressure decreases as the altitude increases; the higher up you go, the less air there is above you. Air pressure is typically measured in inches of mercury by a mercurial barometer. The barometer measures the height of a column of mercury inside a glass tube. A section of the mercury is exposed to the pressure of the atmosphere, which exerts a force on the mercury. An increase in pressure forces the mercury to rise inside the tube. When the pressure drops, mercury drains out of the tube, decreasing the height of the column. This type of barometer is typically used in a laboratory or weather observation station.

Besides altitude, air pressure changes due to the temperature and density of the air. Air molecules are invisible, but they have weight and take up space. Warm air rises because heat causes air molecules to spread apart. As the air expands, it becomes less dense and lighter than the surrounding air. As air cools, the molecules pack together more closely, becoming denser and heavier than warm air. As a result, cool, heavy air tends to sink and replace warmer, rising air. The weather is usually fair in places where the air pressure is higher, and it is cloudy and stormy in places where the air pressure is lower.

As a rule, if the air pressure rises, then the weather stays fair or gets better. If the air pressure drops, then the weather can become cloudy, rainy, or snowy.

Air moves from places where the air pressure is higher to places where the air pressure is lower. This movement of the air is called wind. (This is the same process that occurs when a leak in a balloon allows the air to flow from the high pressure inside the balloon to the lower pressure outside.) On the Earth's surface, the differences in pressure result from the unequal heating of the surface by the sun's energy. Near the equator, the sun's rays strike the surface nearly straight on (at about 90 degrees). The ground and water there receive more heat per area than near the poles, where the rays strike at more of an angle. As a result, the ground in equatorial areas is hotter and transfers more heat to the atmosphere. Since the Earth is always trying to maintain an energy balance, heat is transported from warmer areas to cooler areas.

As one mass of air moves across land and water, it eventually meets another mass of air of a different type. The boundary layer between these two air masses is called a *front*. When you hear that a front is approaching, you know that the weather is going to change soon. There are four types of fronts and each type has a name. The name of each type of front refers to the temperature of the advancing (approaching) air:

Warm front — This front occurs when a warm air mass advances and replaces a colder mass of air. A warm front moves slowly (10-25 miles per hour). A warm front slides up and over the top of the cooler air. The humidity of the warm air in a warm front is often very high. As this warm air lifts over the cooler air, the temperature of the warm air drops and condensation takes place (such as rain, or summer thunderstorms).

Cold front — This front occurs when a cold air mass advances and replaces a warmer mass of air. A cold front moves more quickly than a warm front (20-35 miles per hour, or faster) and changes the weather completely in only a few hours. A cold front moves in the opposite way that a warm front moves. Instead of sliding up and over, a cold front stays close to the ground—because the cold air is more dense than the warm air)—and plows under the warmer air, pushing it upward. Violent weather is possible with a cold front. Because the cold front is moving so quickly, the temperature decreases quickly. As the warm air is pushed higher, clouds form. If it is strong enough, the cold front could create heavy rain showers with lightning, thunder and/or hail. It can also produce tornadoes.

Stationary front — This front occurs when the front between two air masses remains in the same place. This happens when the forces of the two air masses are almost equal. The stationary front can stay in the same place for days. The weather is often a mixture of the weather that a warm front and a cold front can produce.

Occluded front — This front occurs when a fast-moving cold front catches up to a slow-moving warm front. The weather can be a mixture of the weather found with warm and cold fronts or could be more severe.

Humidity refers to the amount of water vapor in the atmosphere at a given time. Air can hold only so much water vapor. When the air contains as much water vapor as it can hold, the air is saturated. As the temperature of the air rises, the amount of water vapor the air can hold also increases. As the temperature drops, the maximum amount of water vapor also decreases.

You have probably heard about relative humidity in weather reports. *Relative humidity* compares the actual amount of water vapor (moisture) in the air to the total amount of moisture the air could hold at that temperature (when the air is saturated). Relative humidity is stated as a percentage. For example, if the relative humidity is 65%, then the air is holding 65% of the total amount of moisture that it can hold at that temperature and pressure.

The *dew point*, stated in degrees, is the temperature at which the air becomes saturated and can hold no more moisture. When the temperature of the air reaches the dew point, the moisture starts to *condense* out of the air in the form of fog, dew, frost, clouds, rain, hail or snow. (Fog is really a cloud that begins within 50 feet of the surface.)

Clouds are a mass of water droplets or crystals that you can see. These droplets or crystals are suspended in the atmosphere. Clouds form where air rises and cools — such as along fronts, when air flows up the side of a mountain and when warm air blows over a colder surface (like cool water). The condensing water vapor creates droplets. Each droplet forms around a particle of salt or dust. They combine with billions of other droplets to form clouds. Clouds are classified by their shapes and by their height:

- Low clouds are usually found below 6,500 feet.
- Middle clouds form between 6,500 and 20,000 feet.
- High clouds form above 20,000 feet.

Words from the Latin language are used to describe the shapes of clouds:

- Clouds that appear in layers are called stratus, which in Latin means “layered.”
- Clouds that look puffy are called cumulus, which is Latin for “heap.”
- High, thin, wispy clouds are called cirrus, which is Latin for “curl of hair.”

Moisture that falls from clouds is called *precipitation*. As each water droplet attracts more and more water, it finally becomes large enough to fall from the cloud. In many clouds, the raindrops start as ice crystals. When they become big enough to fall from the cloud, they pass through warmer air, melt and fall as raindrops.

Source: Adapted from *Technology Learning Activity: Weather and Weather Prediction*, Oklahoma Department of Career and Technology Education

TEACHER BACKGROUND INFORMATION
AVIATION IMPACTS OF WEATHER

Weather is an important factor that influences aircraft performance and flying safety. It is the state of the atmosphere at a given time and place with respect to variables, such as temperature (heat or cold), moisture (wetness or dryness), wind velocity (calm or storm), visibility (clearness or cloudiness) and barometric pressure (high or low). The term "weather" can also apply to adverse or destructive atmospheric conditions, such as high winds.

--Pilot's Handbook of Aeronautical Knowledge, Federal Aviation Administration, 2016

Convective weather is unstable, rising air found in cumiliform clouds. Hazards associated with convective weather include thunderstorms with severe turbulence, intense up- and downdrafts, lightning, hail, heavy precipitation, icing, wind shear, microbursts, strong low-level winds and tornadoes.

Thunderstorms and related phenomena can close airports, degrade airport capacities for acceptance and departure and hinder or stop ground operations. Convective hazards en route lead to rerouting and diversions that result in excess operating costs and lost passenger time.

Lightning and hail damage can remove aircraft from operations and result in both lost revenues and excess maintenance costs.

> Precipitation refers to any type of water particles that form in the atmosphere and fall to the ground. It has a profound impact on flight safety. Depending on the form of precipitation, it can reduce visibility, create icing situations and affect landing and takeoff performance of an aircraft.
>
> Precipitation in any form poses a threat to safety of flight. Often, precipitation is accompanied by low ceilings and reduced visibility. Aircraft that have ice, snow or frost on their surfaces must be carefully cleaned prior to beginning a flight because of the possible airflow disruption and loss of lift. Rain can contribute to water in the fuel tanks. Precipitation can create hazards on the runway surface itself, making takeoffs and landings difficult, if not impossible, due to snow, ice or pooling water and very slick surfaces.
>
> *--Pilot's Handbook of Aeronautical Knowledge,* Federal Aviation Administration, 2016

In-flight icing is a contributing or causal factor in many weather-related accidents among general aviation aircraft. In-flight icing is not only dangerous, but also has a major impact on the efficiency of flight operations. Rerouting and delays of commercial carriers, especially regional carriers and commuter airlines, to avoid icing conditions lead to late arrivals and result in a ripple effect. Diversions en route cause additional fuel and other costs for all classes of aircraft.

Icing poses a danger to aircraft in several ways:

- Structural icing on wings and control surfaces increases aircraft weight, degrades lift, generates false instrument readings and compromises control of the aircraft.

- Mechanical icing in carburetors, engine air intakes and fuel cells impairs engine performance, leading to reduction of power.

Small aircraft routinely operate at altitudes at which temperatures and clouds are most favorable for ice formation, making these aircraft vulnerable to icing for long periods of time. Larger aircraft are at risk primarily during ascent from and descent into terminal areas.

Nonconvective **turbulence** is a major aviation hazard. All aircraft are vulnerable to turbulent motions. Nonconvective turbulence can be present at any altitude and in a wide range of weather conditions, often occurring in relatively clear skies as clear-air turbulence. Any aircraft entering turbulent conditions is vulnerable to damage; smaller aircraft (both fixed- and rotary-wing) are susceptible at lower levels of turbulent intensity than are large aircraft.

The effects of turbulence range from a jostling of the aircraft that is mildly discomforting for passengers and crews to sudden accelerations that can result in serious injury and temporary loss of aircraft control. Clear-air turbulence is not only dangerous, it also has a major impact on the efficiency of flight operations due to rerouting and delays of aircraft.

Low ceiling and reduced visibility are safety hazards for all types of aviation. Low ceiling and poor visibility are not just a safety issue. They can also severely degrade the efficiency of commercial and military aviation. Reduced ceiling and/or visibility can severely reduce the capacity of an airport and lead to airborne or ground delays that result in diversions, cancellations, missed connections, and extra operational costs.

Aircraft **on the ground** during periods of freezing or frozen precipitation and other icing conditions are susceptible to the buildup of ice on control surfaces, instrument orifices, propellers and engine inlets and interiors. Aircraft that are moving along taxiway and runway surfaces in slush or standing water at near-freezing conditions are also susceptible to surface contamination, even after precipitation has stopped. Even a very small amount of ice on a wing surface can increase drag and reduce airplane lift by 25 percent.

Ice and snow also have an impact on terminal operations. Boarding gates, taxiways and runways may become unusable. Airport operational capacities may be sharply reduced.

Source: Adapted from “Weather and Aviation: How Does Weather Affect the Safety and Operations of Airports and Aviation, and How Does FAA Work to Manage Weather-related Effects?,” https://trid.trb.org/view/663829

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?

A-Z REVIEW
Student Reflection Worksheet

Your Name:_____ Date:_____

Instructions

- Think about what you have learned today.
- Write a word about what you have learned in each letter box. The word does not need to begin with that letter. Try to think of words others haven't used.
- At the end of the time given, you will get points for each word that applies. You will also get points for words no one else has written down.

Note: This activity can be done in groups or individually; your instructor will decide. Your instructor will decide the bonus for the winning individual or team.

A		**N**	
B		**O**	
C		**P**	
D		**Q**	
E		**R**	
F		**S**	
G		**T**	
H		**U**	
I		**V**	
J		**W**	
K		**X**	
L		**Y**	
M		**Z**	

EXIT TICKET

EXIT TICKET

OKLAHOMA IS AVIATION

Name ____________________ Date __________

Three things I learned today:

Two ways I contributed to class today are:

Two Important facts/details:

1 question I have for tomorrow:

EXIT TICKET

OKLAHOMA IS AVIATION

Name ____________________ Date __________

Three things I learned today:

Two ways I contributed to class today are:

Two Important facts/details:

1 question I have for tomorrow:

CAREER REFLECTION WORKSHEET

Name: _____ Date: _____

Instructions

- Many factors go into deciding what career might be a good fit for you. You can be proactive and start researching careers to help you decide a career path.
- Choose 1-3 careers in Aviation & Aerospace Pathways that interest you. Use the career pathways videos and other resources that your instructor provides. Answer the questions below for each career.

1. List the career. Why does this career interest you?

2. What tools and technology does this career use? How would they make the job easier?

3. What knowledge is important to have for this career? Why is it important?

4. What skills and abilities are important to have for this career? Why are they important?

5. What work activities in this career might relate to things you already do at school, at home or at a job?

6. What about the work environment for this career would interest you?

7. Where can you develop the skills and abilities for this career?