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Agricultural Drones

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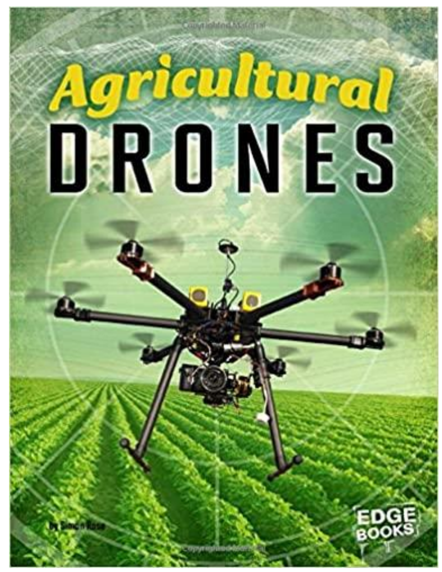
SCAN ME

"Farm fields can span hundreds of acres. With so much area to cover, checking crops and livestock can be difficult. But with an agricultural drone, this job becomes much simpler. Readers will discover how drones help farmers maximize efficiencies and bring abundant harvest. Learn how agricultural drones help farmers solve problems and what drone technology could mean to future generations of farmers!" [1]



Did You Know? (Ag Facts)

- Drones are also called unmanned aerial vehicles (UAVs).
- Drones have been used for sheep herding purposes before, much like a farmer would use a herding dog, and as scarecrows to ward off pests.
- Some researchers are building agricultural drones with robotic arms. These drones could someday pick pests off plants.
- One drone can survey and collect data on a ten-acre field in less than five minutes, while it would take a person days or weeks to do the same.

Discussion Questions

- How are drones used by crop farmers? Livestock farmers?
- What are the advantages of using drones on farms?
- Why do governments makes laws about drone use?

Grade Level(s): 3-6

Purpose: Students will discover the science behind how a drone works and explore how drones are used in agriculture.

Vocabulary:

- **drone:** an unmanned aircraft guided by remote control or onboard computers
- **force :** a push or a pull on an object
- **Global Positioning System (GPS):** a space-based satellite navigation system that provides location and time information in all weather conditions, anywhere on or near the Earth
- **gravity:** the natural force that causes things to fall toward the Earth
- **hover:** remain in one place in the air
- **lift:** the force that directly opposes the weight of an aircraft and holds the aircraft in the air
- **pitch:** movement of a drone up or down on a lateral axis
- **precision agriculture:** an information technology-based site-specific farm management system that collects and responds to data ensuring that crops receive exactly what they need for optimum health and productivity
- **propulsion:** the force that moves something forward
- **quadcopter:** a drone with four rotors
- **remote control:** a device used to control machines from a distance
- **roll:** rolling movement of a drone sideways left or right on a longitudinal axis
- **rotor:** a set of rotating blades that turn around a central point and lift an aircraft off the ground
- **satellite:** a spacecraft placed in orbit around the Earth, moon, or another planet used to send signals and information as part of a communications system
- **survey:** to measure and examine an area of land
- **thrust:** the force that causes an aircraft to move forward
- **yaw:** rotating movement of an aircraft clockwise or counterclockwise on a vertical axis

Background Agricultural Connections: [3]

A **drone**, also known as an unmanned aerial vehicle (UAV), is an unmanned aircraft guided by remote control or onboard computers. Most agricultural drones have either fixed wings or **rotors**. Drones with four rotors are called **quadcopters**.

Drone applications in **precision agriculture** include mapping, **surveying**, monitoring, planting, crop dusting, and spraying. Drones can increase yields, save time and money, and assist with animal and crop monitoring, planning, and management. The birds-eye-view of a drone can improve production, efficiency, and yields by identifying small problems before they become big problems. Real-time footage can prevent costly losses and ensure the success of the crops.

Drone map creation provides farmers with an accurate view of their fields. Drones equipped with near infrared camera sensors allow the drones to see the spectrum of light that plants use to absorb light for photosynthesis. Using this information, farmers can identify the health of their crop. Drones can create detailed **Global Positioning System (GPS)** maps for planning the location of planting to maximize land, water, and fertilizer usage. Precise soil analysis maps produced by drones help direct seed planting patterns, irrigation, and nitrogen-level management. Nutrients, moisture levels, and overall crop health is monitored in real time by drones equipped with hyper-spectral, multispectral, and thermal sensors. Scanning crops with visible and infrared (IR) light, drones can identify plants infected by bacteria or fungus, helping to prevent disease from spreading to other crops. This technology enables detection of some diseases before they are visible to the human eye.

Drone cameras can take high-resolution images with clear detail. Drones equipped with thermal cameras can assist with irrigation decisions by identifying areas of pooling water or insufficient soil moisture. Thermal imaging cameras can also monitor livestock by checking the herd for injured, sick, missing, or birthing livestock. Drones provide greater resolution than **satellites** or airplanes because they can be flown lower and more precisely.

Crop spraying drones can carry fertilizer, herbicides, pesticides, or fungicides in large liquid storage reservoirs. Applications using drones are less expensive than manual vehicle applicators or crop dusters. Drones follow pre-mapped flight paths and spray crops with precision and accuracy, which can reduce waste and over spraying.

Drones can be operated by **remote control** or by onboard computers with a preset flight path. The flight path of a drone is created by the user on a ground control device (a laptop, tablet, or smartphone). The line of flying is drawn on a map, and the information is transferred or uploaded wirelessly from the ground control device to the drone. The drone follows this flight path, and the user has the option to perform manual overrides if necessary.

Drones with rotors, like quadcopters, use the rotors for **propulsion** and control. A rotor is like a fan. Spinning blades push air down. Two of the rotors diagonally opposite of each other are spinning clockwise while the other two rotors are spinning counterclockwise. According to Newton's third law of motion, for every action there is an equal and opposite reaction, all **forces** come in pairs. As the rotor pushes down on the air, air pushes up on the rotor. In order for the drone to fly into the air, a force that equals or exceeds the force of **gravity** must be created. This is called **lift**. The faster the rotors spin, the greater the lift. Drones can **hover**, climb, or descend. To hover, the **thrust** of the rotors pushing the drone up must be equal to the gravitational force pulling it down. By increasing the thrust (speed of the rotors), the upward force is greater than the force of gravity and the drone will climb. By decreasing the thrust, the drone will descend.

Yaw is the rotating of the drone either clockwise or counterclockwise on a vertical axis. A drone with four rotors can rotate by changing the power to the four rotors. Decreasing the spin of two rotors diagonally opposite from each other and increasing the spin of the other two rotors causes the drone to rotate while hovering.

Pitch is the movement of the drone either up or down on a lateral axis. Moving the front of the drone up requires increasing the rotation rate of the back two rotors and decreasing the rate of the front two rotors. Decreasing the rotation rate of the back two rotors and increasing the rate of the front two rotors will move the front of the drone down.

Roll is the rolling movement of the drone sideways, either to the left or the right, on a longitudinal axis. Increasing the rotation rate of the right two rotors and decreasing the rate of the left two rotors will move the drone to the left. Decreasing the rotation rate of the right two rotors and increasing the rate of the left two rotors will move the drone to the right.

The ascent, descent, yaw, pitch, and roll on most quadcopters can be controlled by the throttle sticks on the remote control or by programming a flight plan.

All drones that weigh more than .55 pounds (250 grams) must be registered with the Federal Aviation Administration (FAA). Unmanned aircraft should stay below 400 feet. Everyone flying drones should follow these basic safety guidelines at all times:

- Keep the drone in eyesight at all times, and use an observer to assist if needed.
- Remain well clear of and do not interfere with manned aircraft operations. See and avoid other aircraft and obstacles at all times.
- Do not intentionally fly over unprotected persons or moving vehicles. Remain at least 25 feet away from individuals and vulnerable property.
- Contact the airport and control tower before flying within five miles of an airport or heliport.
- Do not fly in adverse weather conditions such as high winds or reduced visibility.
- Do not fly under the influence of alcohol or drugs.

- Ensure that the operating environment is safe and that the operator is competent and proficient in the operation of the drone.
- Do not fly near or over sensitive infrastructure or property such as power stations, water treatment facilities, correctional facilities, heavily traveled roadways, government facilities, etc.
- Check and follow all local laws and ordinances before flying over private property.
- Do not conduct surveillance or photograph persons in areas where there is an expectation of privacy without the individual's permission.

The FAA mobile app B4UFLY is useful for locating no-fly zones.

Before using drones within an educational setting, consult with district administration to evaluate district and school policies, local regulations, and legal implications. Laws surrounding drone use change frequently. For up-to-date information, go to knowbeforeyoufly.org. Information specific to the educational use of drones can be found on the Know Before You Fly Educational Use webpage. The book *Drones in Education* by Chris Carnahan, Laura Zieger, and Kimberly Crowley provides recommendations and information about classroom implementation.

How Do Drones Fly? [3]

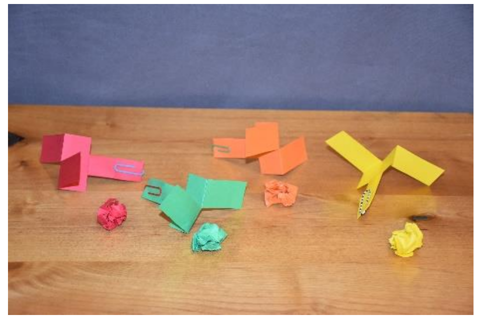
Materials:

- Hair dryer
- Ping pong ball
- 2" x 6" piece of paper, 2 per student
- Paper clip, 1 per student
- Scissors
- Rulers
- Quadcopter drone
- How Do Drones Fly? video

Procedures:

1. Ask the students, "How do drones fly?" After listening to their responses, lead a discussion about gravity and lift. Integrate the following points into the discussion:
    a. Gravity is the natural force that causes things to fall toward the Earth.
    b. Lift is the force that directly opposes the weight of the aircraft and holds the aircraft in the air.
    c. Quadcopter drones use rotors to help the drone lift off the ground and fly.
    d. As the rotor pushes down on the air, air pushes up on the rotor.
    e. In order for the drone to fly into the air, a force that equals or exceeds the force of gravity must be created. This is called lift.
    f. The faster the rotors spin, the greater the lift.
2. Turn on a hair dryer and aim it towards the ceiling. Place a ping pong ball into the stream of air. Ask the students, "Why is the ping pong ball floating?" (*The force of the air pushing up on the ball is equal to the force of gravity pushing down on the ball, so the ball is hovering in the air.*)

3. Ask the students what they think will happen to the ping pong ball if the hair dryer is turned off. Turn the hair dryer off to show the students that the ball will fall to the ground. Ask the students, "Why does the ping pong ball fall when the hair dryer is turned off?" (*The force of the air pushing up on the ball is less than the force of gravity pushing down on the ball.*)
4. Hand out two 2" x 6" pieces of paper and a paper clip to each student. Instruct the students to crumple one of the pieces of paper into a ball. Use the following instructions to make a rotor with the other piece of paper.
    a. Hold the paper so that the 2" edges are at the top and bottom.
    b. Fold the paper in half vertically.
    c. Unfold the paper, and draw a horizontal line 2" from the top and a horizontal line 3" from the bottom.
    d. From the top, cut down the middle fold to the 2" line. Fold one of the flaps forward and the other flap backward on the line to make the rotor's blades.
    e. On the other line, make a mark 5/8" from the right. Make a cut along the line from the right stopping at the 5/8" mark.
    f. On the same line, make a mark 5/8" from the left. Make a cut along the line from the left stopping at the 5/8" mark.
    g. Draw a line from each 5/8" mark to the bottom of the paper. Fold the paper into the middle along each of these lines.
    h. Draw a horizontal line 1" from the bottom. Fold the paper along this line and place a paper clip on the fold.



5. Have the students carefully stand on their chairs and drop their crumpled ball and their rotor (paper clip facing down) at the same time from the same height.
6. Ask the students, "Which stayed in the air the longest, the crumpled ball or the rotor?" (*the rotor*) "Why did the rotor stay in the air longer?" (*The design of the rotor causes the blades to spin as it falls through the air. The spinning blades generate enough lift to slow the rotor down.*)
7. Show the students the rotors on the quadcopter drone. Clarify that, unlike the paper rotor, the drone's rotors are powered by motors that can create and maintain a force that is equal to or greater than the force of gravity. The rotors help the drone lift off the ground and fly.
8. Show the students the video How Do Drones Fly? for an explanation of how rotors help drones move in different directions.

Drones in Agriculture [3]

Materials:

- *Agricultural Drones* by Simon Rose, 1 per group
- Agricultural Drones Discussion Guide, 1 per student

Procedures:

1. Organize the class into three groups. Handout an Agricultural Drones Discussion Guide to each student, and provide each group with a copy of *Agricultural Drones* by Simon Rose. Assign one group to read chapter 2, one group to read chapter 3, and one group to read chapter 4.
2. After reading their assigned chapter together, have each group discuss the chapter and work together to complete the corresponding section of the *Agricultural Drones Discussion Guide*.
3. Reorganize the class into groups of three students that include a representative from each of the three chapters. Each representative should take a turn summarizing their assigned chapter and help the rest of the group complete that section of the *Agricultural Drones Discussion Guide.*
4. After the discussion guides have been completed, lead a class discussion about general crop problems. Integrate the following points into the discussion:
    a. When insect pests eat crops, the plants do not thrive. Pesticides are substances used to destroy harmful insects.

b. When weeds invade crops, they compete with the plants for water, nutrients, and sunlight. Herbicides are substances used to destroy weeds.
c. When plants do not receive enough water, they wilt and eventually die. Irrigation is the application of controlled amounts of water to plants.
d. When plants do not receive the proper nutrients, they grow slowly and turn yellow. Fertilizers are substances that supply nutrients to plants.
e. Pesticides, herbicides, and fertilizers can be part of either organic or conventional farming practices, depending on the specific types that are being used.

Extension Activities:

- View the videos Cow Art with a Drone, #CowPi, and #CowHeart to explore the creative uses of drones on farms.
- View the video on Drones in Agriculture and have a discussion with students.
    - Video Discussion Questions:
      1. What are some of the reasons Jeff Sandborn gives for embracing agricultural technology?
      2. According to Bruno Basso, why is a uniform application of fertilizer a waste?
      3. How do drones help farmers use fertilizer more efficiently? What is the outcome for farmers who use the drone?
      4. How does the software Bruno Basso is developing help farmers?

Suggested Companion Resources:

- Agricultural Drones
- Agricultural Inventions: At the Top of the Field
- The Magic School Bus Rides Again: Robot Farm
- Drones and the Future of Farming Video
- How Drones are Helping to Plant Trees - A Cleaner Future
- What Happens When Farming Goes High-Tech?

Sources/Credits:

1. Rose, Simon. *Agricultural Drones*, Capstone, 2017.
2. North Carolina Ag in the Classroom
3. National Center for Agricultural Literacy

Suggested SC Standards Met:

English/Language Arts:

- 3.RI.5.1 Ask and answer literal and inferential questions to determine meaning; refer explicitly to the text to support inferences and conclusions.
- 3.RI.8.1 Explain how the author uses words and phrases to inform, explain, or describe.
- 3.RI.8.2 Use knowledge of appendices, timelines, maps, and charts to locate information and gain meaning; explain how these features contribute to a text.
- 3.RI.10.1 State the author's purpose; distinguish one's own perspective from that of the author.
- 4.RI.5.1 Ask and answer inferential questions to analyze meaning beyond the text; refer to details and examples within a text to support inferences and conclusions
- 4.RI.8.1 Determine how the author uses words and phrases to shape and clarify meaning.
- 4.RI.8.2 Apply knowledge of text features to gain meaning; describe the relationship between these features and the text.
- 5.RI.8.1 Analyze how the author uses words and phrases to shape and clarify meaning.
- 6.RI.5.1 Cite textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text.

- 6.RI.7.1 Integrate information presented in different media or formats to develop a coherent understanding of a topic or issue.

Science:

- 3.S.1: The student will use the science and engineering practices, including the processes and skills of scientific inquiry, to develop understandings of science content.
- 4.S.1: The student will use the science and engineering practices, including the processes and skills of scientific inquiry, to develop understandings of science content.
- 5.S.1: The student will use the science and engineering practices, including the processes and skills of scientific inquiry, to develop understandings of science content.
- 5.P.5: The student will demonstrate an understanding of the factors that affect the motion of an object.
- 6.S.1: The student will use the science and engineering practices, including the processes and skills of scientific inquiry, to develop understandings of science content.
- 6.P.3: The student will demonstrate an understanding of the properties of energy, the transfer and conservation of energy, and the relationship between energy and forces

Agricultural Drones Discussion Guide

Chapter 2: Eyes in the Sky

1. How are agricultural drones similar to other drones?

2. How are agricultural drones different from other drones?

3. How are drones used by crop farmers?

4. How are drones used by livestock farmers?

5. What are the advantages of using drones on farms?

6. What are the benefits of gathering images from a drone's camera instead of a satellite?

7. Who sets the rules for drone use in the United States?

8. Name three rules for drone use in the United States.

Chapter 3: Drone Parts and Features

1. What are two ways that a drone can be flown?

2. Describe the differences between fixed-wing drones and rotor drones.

3. Describe the three different types of cameras typically carried by agricultural drones.

4. Name two things that can be measured by drone sensors.
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____

5. What are drone bodies made of?
____

6. How are drone motors powered?
____

7. What does GPS stand for and how does it work?
____
____
____

Chapter 4: Flying into the Future

1. Which type of business is most likely to use drones?
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2. What are two reasons for the increased use of drones?
____
____

3. What is the predicted world population in 2050?
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4. Because people need to eat, a population increase means more ________ will need to be produced.

5. In what type of countries is the population expected to increase the most by 2050?
____

6. Which continent has the largest number of least developed countries?
____

7. Why do governments make laws about drone use?
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