LESSON 6: HEXAGON

Overview:

Students will investigate the geometry of a hexagon, examining interior and supplementary angles. They will use the DroneBlocks program to fly their aircraft in a unique hexagon pattern, using accurate angles and distances. This lesson will build on skills and navigational learning discovered in the previous DroneBlocks lessons. The loop concept introduced in **Lesson 3** will also be applied. Flexible activities and extension lesson ideas are included to provide opportunities for students and teachers to add depth to their learning.

Objective:

Students will:
- Learn and/or revisit the angles and calculations of a regular hexagon
- Calculate and determine program blocks for altitude, distance, and yaw
- Run a test-flight of the program through a flight Preview Mission
- Launch a field mission that will take their drone in a hexagonal flight path

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Common Core State Standards:

Common Core Standards provided focus on grades 5 and 6, as a baseline. Educators should adjust standards based on the ability and/or experience of their students.

CCSS.MATH.CONTENT.5.G.B.3: Understand that attributes belonging to a category of two-dimensional figures also belong to all subcategories of that category. For example, all rectangles have four right angles and squares are rectangles, so all squares have four right angles.

CCSS.MATH.CONTENT.5.OA.A.2: Write simple expressions that record calculations with numbers, and interpret numerical expressions without evaluating them.

CCSS.ELA-LITERACY.RST.6-8.3: Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

CCSS.MATH.CONTENT.6.EE.A.1: Write and evaluate numerical expressions involving whole-number exponents.

CCSS.MATH.CONTENT.6.G.A.1: Find the area of right triangles, other triangles, special quadrilaterals, and polygons by composing into rectangles or decomposing into triangles and other shapes; apply these techniques in the context of solving real-world and mathematical problems.

CCSS.MATH.CONTENT.6.G.A.3: Draw polygons in the coordinate plane given coordinates for the vertices; use coordinates to find the length of a side joining points with the same first coordinate or the same second coordinate. Apply these techniques in the context of solving real-world and mathematical problems.

International Society for Technology in Education Standards:

ISTE 1.a Apply existing knowledge to generate new ideas, products, or processes

ISTE 1.c Use models and simulations to explore complex systems and issues

ISTE 2.a Interact, collaborate, and publish with peers, experts, or others employing a variety of digital environments and media

ISTE 2.b Communicate information and ideas effectively to multiple audiences using a variety of media and formats

ISTE 2.d Contribute to project teams to produce original work or solve problems

ISTE 3.a Plan strategies to guide inquiry

ISTE 3.c Evaluate and select information sources and digital tools based on the appropriateness to specific tasks

ISTE 3.d Process data and report results

ISTE 4.a Identify and define authentic problems and significant questions for investigation

ISTE 4.b Plan and manage activities to develop a solution or complete a project

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Materials Needed:

- Supplies such as Paper, Pencil, Protractor (as outlined in **Part 2**)
- Pre-Flight Checklist
- DroneBlocks App Downloaded on iOS devices for students
- Drone
- Propeller Guards
- Class social media page or blog to share your success!

Part 1: Vocabulary

Introduce the following vocabulary to your students:

Regular Hexagon – A polygon with six equal angles and six equal sides.

Interior Angles – An angle formed by two adjacent sides within a polygon.

Supplementary Angles - Two Angles are Supplementary when they add up to 180°.

Part 2: Calculating the Yaw Angle at Each Point of the Hexagon

This mission is called "Hexagon" because students will program the aircraft to fly in a hexagonal shape around the flying area. The cumulative concept is to program a mission that commands the drone to take off, then navigate in a hexagonal pattern.

Included in this section are engaging ideas to guide you to determine what to reinforce while teaching the angles of a hexagon. Whether you direct your students to discover the angle by calculating a formula, challenge them to discover the angles online, or dive deep into a lesson of calculating and displaying diagrams of the hexagon, here are the key components of the Hexagon mission:

- Takeoff to altitude (recommend 50 feet or a height that is clear of nearby obstacles)
- Repeat, or loop the following sequence 6 times
  - Fly forward a distance (recommend 25 feet)
  - Yaw right or left 60°
- Land

In order to properly complete this mission, students must calculate the turning angle at each point in the hexagon. This is often more difficult than it sounds and provides an excellent opportunity to teach key geometry concepts!

The first step is to calculate the angle at each point in the hexagon. You may guide your students to conduct simple research and discover the angles on the Internet, but first, share with them the trick below for calculating the sum of the interior angles in any polygon, as shown in **Figure 6.1**.

Remember, triangles have interior angles that sum to 180°. We can divide our hexagon into triangles then multiply the number of triangles we find by 180°.

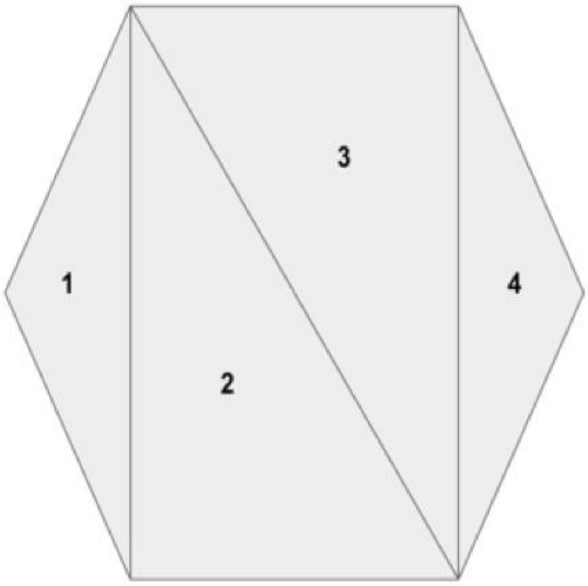

Figure 6.1

Since there are 4 triangles in a hexagon, we calculate the total interior angles of the hexagon using the equation, 4 x 180, which equals 720. Now that we know there are 720°, we can calculate each angle by dividing by 6. Therefore, 720 divided by 6 equals 120. Each interior angle of the hexagon is 120°.

Depending on the grade level in which you are teaching and even the time of year in which this lesson is being conducted, your approach to teaching this concept may vary.

Here are activity ideas that will help students understand the angles of a hexagon. It is good practice to give students options of which activity they would like to choose or engage as a group. Have fun!

Activities to Discover the Angles of a Hexagon

Back to Basics:

Have your students get out the construction paper, craft sticks, glue, protractors, or markers! Using the "4 Triangle" trick in **Figure 6.1** above, or by simply measuring each length, have students draw then measure the angles with a protractor. Ask them to get creative and begin calculating. **Figure 6.2** shows a student example of exploring hexagons with just rulers, paper, and scissors.

Use a ruler and protractor to measure and draw a regular hexagon. Cut the hexagon into four triangles to make your own tangrams then find the interior angles of each triangle. Using a protractor or protractor app, measure each angle. When the angles are added together, what is the total amount of interior ° for each triangle? What is the total amount of interior ° for the hexagon?

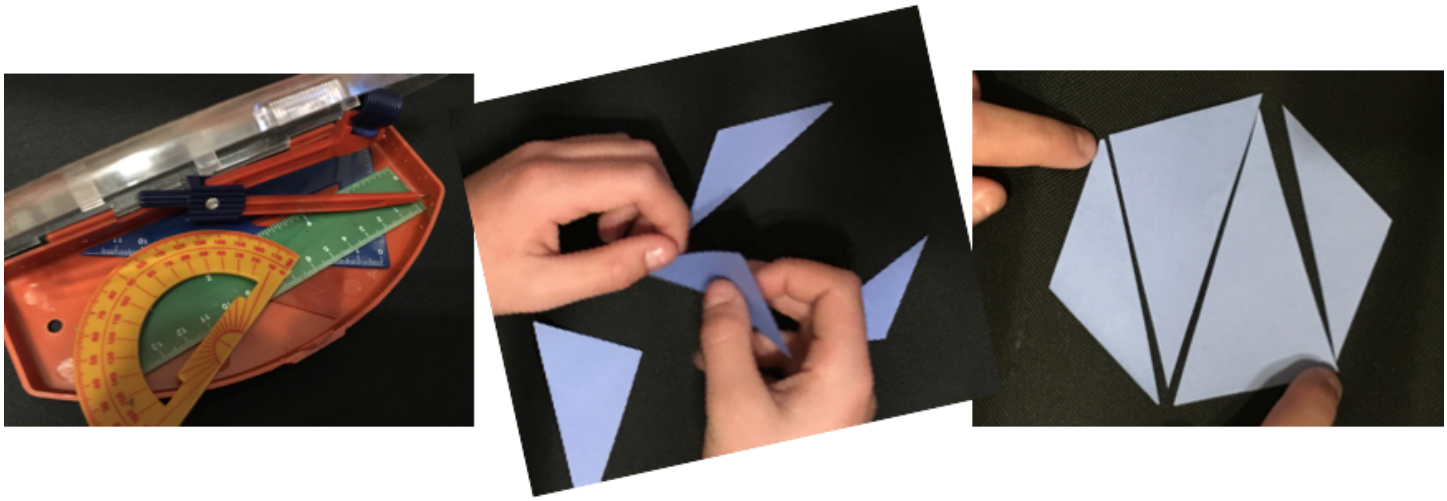

Figure 6.2

Do Some Drawing:

Ask students to measure and draw a regular hexagon. Next, have them research and explain why the drone must be programmed to yaw, or turn, 60°, as opposed to 120° (which is the interior angle of each vertex). (Hint: supplementary angles!) Use pencil and paper or allow students to create their diagrams digitally. Both methods provide a hands-on opportunity to measure, create, and design.

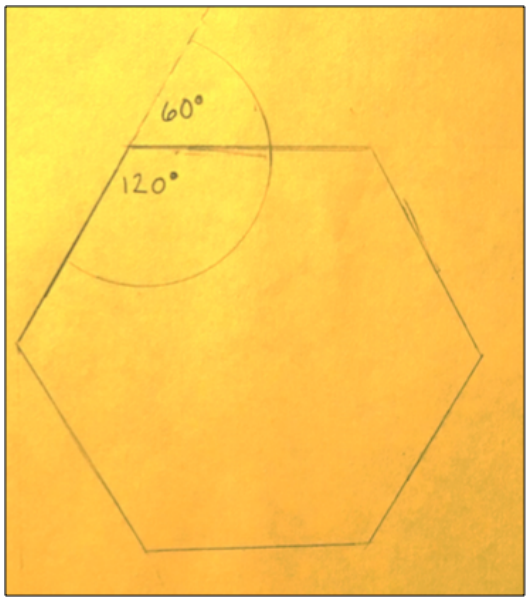

Figure 6.3

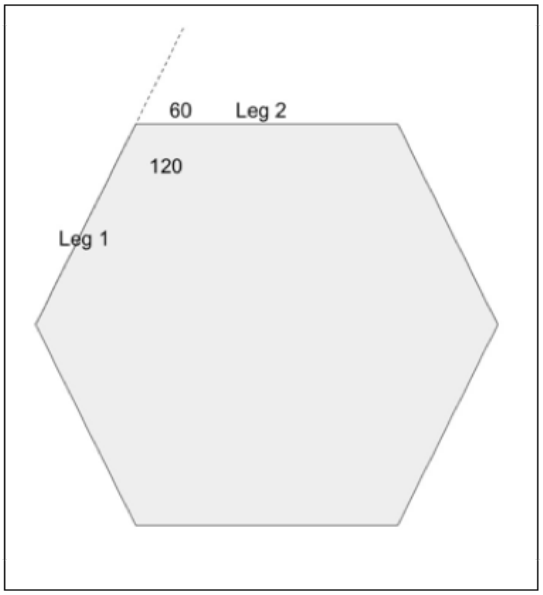

Figure 6.4

Educator Note: Use this point in the lesson as a problem-solving opportunity! Some students will get confused at this point and attempt to program a yaw of 120° in their mission, which would be a mistake -- producing a star-like flight pattern. In **Figure 6.4**, you see that after completing leg 1, the path of the drone will be in the direction of the dotted line. So it must turn 60° (the two angles are "supplementary" in that they must add to 180°).

Flip Your Classroom:

Be the student! Ask your students to create a lesson in pairs or small groups. Give students the end product then ask them to enlighten you! In addition to the examples we have provided, there are many ways to explain how to determine the angles: find the sum of angles, and the supplementary angles of a hexagon. They might choose to draw a diagram and narrate the process, make a video, or design a game. You may be surprised at what your students learn and teach you! **Figure 6.5** shows one example of a diagram lesson:

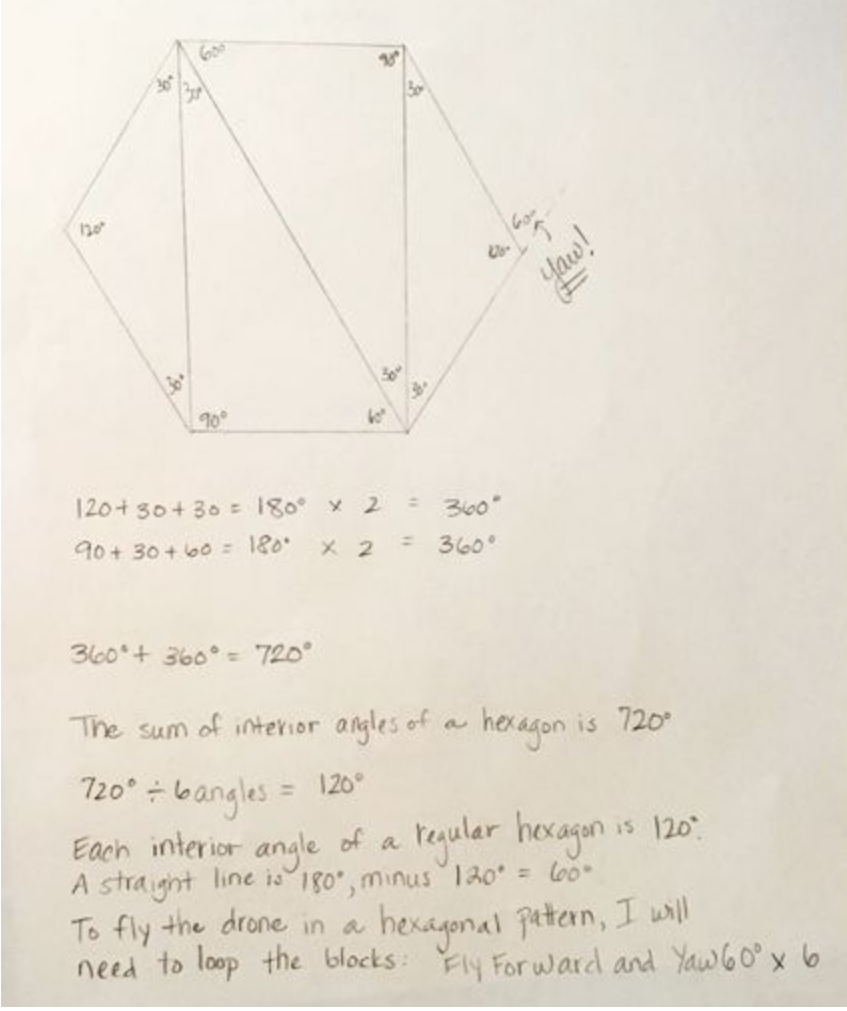

Figure 6.5

You may use any of these activities or use the programmed missions as an assessment. Encourage students to share their creations on social media. Post pictures of their work or presentations from which students across the globe can learn!

Did you know? The "miniature computers" we use daily, aka smartphones and tablets, are capable of measuring angles and distance. They contain accelerometers, which sense gravity and magnetic field sensors that locate the direction of Magnetic North. Do you think using a digital device to measure angles is reliably accurate? What tools might your device replace and how might it be used in the real world?

Part 3: Programming the Mission Plan

Students should now have the knowledge to code their Hexagon mission in the DroneBlocks program. Once again, the key components of the Hexagon are as follows:

- Takeoff to altitude (recommend 50 feet or a height that is clear of nearby obstacles)
- Loop or repeat the following sequence 6 times
  - Fly forward a distance (recommend 25 feet)
  - Yaw right or left 60°
- Land

The following is a loop example of the hexagon mission program:

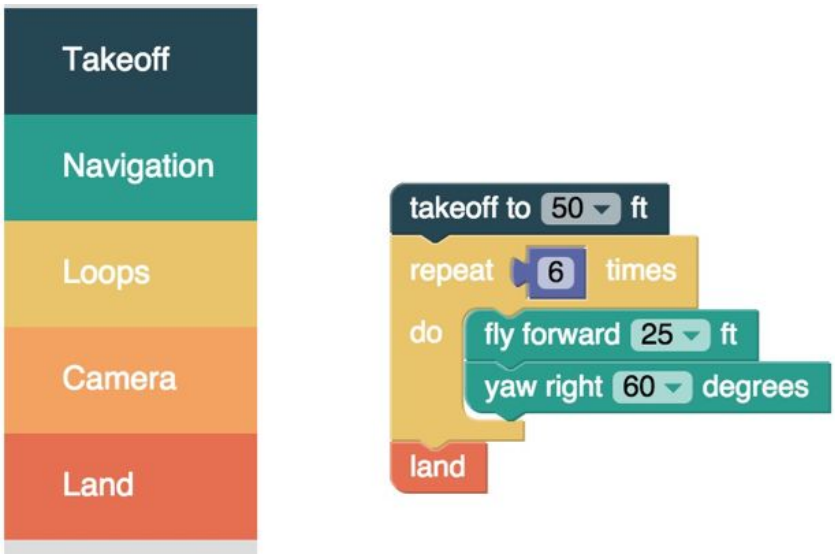

Figure 6.6

Students may individually program this mission on their own or in teams. Let your students explain their missions and run them in "Preview Mission".

REMEMBER:

- When running preview missions indoors, the aircraft and remote should be powered off.
- Never let the students connect to the aircraft indoors, as they could accidentally activate the mission, resulting in an extremely dangerous indoor flight.

Previewing missions allows you to see if your mission is programmed correctly. When programming you may forget a simple instruction. Seeing the code run on the preview simulator is a clear indicator of what needs to be fixed.

Part 4: Field Mission

Now that the mission has been reviewed by the teacher and run in the mission preview, it is time to take the program to the field. Most of the hard work has been completed and now it is time to enjoy the rewards of students' programming and testing. Before running the mission in the field make sure to review the safety steps as you have done previously. These steps will apply to every field mission.

IMPORTANT:

- Take a copy of the Pre-Flight Checklist to the flying area, and complete every step of the pre-flight checklist before running the mission.
- As the Phantom 3 is flying, always be prepared to manually take control of the aircraft if it behaves unexpectedly by switching back to P-mode. If operating a Phantom 4, manually resume control by switching to S-mode. Click here for a video discussing flight modes.
- Note: As tempting as it may be to take a photo directly beneath your drone, don't ever do this. You should not operate a drone above or within 25 feet of people under any circumstances.

Your mission is now complete! Share your photos and creations with @droneblocks and tag us #droneblocks so that we can see your hard work. This is an opportunity to let the world see what you have programmed and created!

With this particular mission, choosing your launch point will be CRITICAL.
Orient your drone AWAY from the group so that it does not fly over students.
Be sure you have sufficient space along the flight path.

Did you know? Like squares and equilateral triangles, regular hexagons fit together without any gaps. What is this type of pattern called?

Part 3: Extensions

Challenge:

Ask students to change the length of each "fly forward" block to 50 feet. Allow the mission to orbit the group and take a dronie from each point.

Do not forget the safety guidelines!
Position the group so that the drone will NEVER fly directly overhead!

Go Natural:

Nature is made up of geometric shapes and lines. Where do you see hexagons in nature? Grab a microscope or camera and see what you can find. Look online for open-source photographs of objects in nature with a hexagonal shape. Need some hints? Begin with turtle shells, snowflakes, and beehives! Integrate your discoveries with your program or dronie photographs and share.

Educator note: While conducting research for preparing this lesson, we noticed there are thousands of tweets and posts on social media that discount having to learn angles and calculations such as the sum of internal angles of hexagons, just as conducted in this lesson! At some point in education, we have all probably thought, "When will I ever use this?" Ask your students the same question. When will they ever use this knowledge? Begin a list to provide your students with a real-world connection. Here are a few ideas to start your list:

Architect
Tile Layer
Engineer
Air Traffic Controller
Graphic Designer
Minecraft Mod Creator
Interior Designer
...What else?

Snap photos of your creations, lists, and DroneBlocks mission. Don't forget to tag us @DroneBlocks so we can follow you and be blown away by your learning. Never underestimate the power of sharing and learning on a global scale. There is so much to learn so "show what you know" and always practice digital safety!

Additional Resources

Would you like to download a protractor app?

Try one of these free apps:

https://itunes.apple.com/us/app/protractor-practical-angle/id982829507?mt=8

https://itunes.apple.com/us/app/protractor-angle-meter-tool/id631311541?mt=8

https://itunes.apple.com/us/app/sum-exterior-angles-polygons/id464586818?mt=8

Would you like to learn more about hexagons in nature?

Start with these websites:

http://www.npr.org/sections/krulwich/2013/05/13/183704091/what-is-it-about-bees-and-hexagons

https://www.cs.cornell.edu/cv/OtherPdf/FabHex.pdf

https://www.quora.com/Why-does-nature-prefer-hexagonal-shapes

Would you like to learn more about supplementary angles?

Start with these websites:

https://www.khanacademy.org/math/geometry/parallel-and-perpendicular-lines/complementary-supplementary-angl/v/complementary-and-supplementary-angles

http://www.virtualnerd.com/pre-algebra/geometry/parallel-lines-angle-relationships/define-angles/supplementary-angles-definition

http://www.pbslearningmedia.org/resource/mapt-math-ee-intangles/looking-at-math-from-different-angles-complementary-supplementary-vertical-and-adjacent/