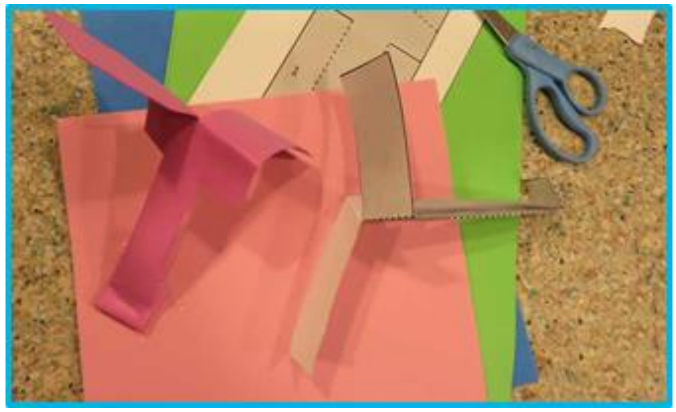
Lesson Focus

Lesson focuses on helicopters and drones, how they fly, how they are used in different ways that helps people and the environment. Teams of students explore helicopter flight; and design, build, and test their own simple rotor out of basic materials.



Lesson Synopsis

The "Designing Drones" lesson explores how helicopter flight is possible and how drones (or quadcopters) have impacted our world. Students explore the forces that make helicopter flight possible, and learn about how material choice and shape can also have an impact on flight. Students work in teams to design, build and fly a simple rotor using basic materials that drops the slowest from a height of ten feet.

Age Levels

8-12.

Objectives

- Learn about the forces that impact flight.
- Learn about engineering design, testing, and troubleshooting.
- Learn how engineering can help solve society's challenges.
- Learn about teamwork and problem solving.

Anticipated Learner Outcomes

As a result of this activity, students should develop an understanding of:

- flight
- engineering design
- materials selection
- teamwork

Lesson Activities

Students learn about helicopter flight and work in teams to design, build, and test a rotor from simple materials or precision program a drone.

Alignment to Curriculum Frameworks

See curriculum alignment sheet at end of lesson.

Internet Connections

- TryEngineering (www.tryengineering.org)
- NASA What is a Helicopter (www.nasa.gov/audience/forstudents/5-8/features/nasa-knows/what-is-a-helicopter-58.html)
- NASA Updrafts and Downdrafts (www.grc.nasa.gov/www/k-12/airplane/move4.html)
- FAA Unmanned Aircraft Systems (www.faa.gov/uas)

Recommended Reading

- "How Do Helicopters Work?" by Jennifer Boothroyd (ISBN: 978-1467707848)
- "How Does a Helicopter Work?" by Sarah Eason (ISBN: 978-1433934650)
- "Flight" by Philip Wilkinson (ISBN: 978-0195219968)
- "Drones: An Illustrated Guide to the Unmanned Aircraft that are Filling Our Skies" by Martin J. Dougherty (ISBN: 978-1782742555)

Optional Drone Kits

If budgets allow, and as an extension idea, there are several kits to allow teams of students to build and even program a drone. The costs for these kits are continuing to drop at the basic level. At the moment you can get a basic but good drone kit for between $30-50. When using drone kits, be sure to arrange for a large open space where no people could possibly be in the way of the flying drone. A large school field is recommended and be sure to get approval from school administration.

- Sky Viper s1750 Stunt 2017 Edition Drone ($50)
- Syma X11 R/C Quadcopter ($30)
- Holy Stone HS170 Predator Mini RC Helicopter Drone ($40)

Optional Writing Activity

- Write an essay or a paragraph describing a situation where a helicopter or drone would be a more efficient flight vehicle than a plane. Or, write an essay about how drones are used in agriculture or by real estate salespeople.

For Teachers:
Teacher Resource

Lesson Goal

The "Designing Drones" lesson explores how helicopter flight is possible and how drones (or quadcopters) have impacted our world. Students explore the forces that make helicopter flight possible, and learn about how material choice and shape can also have an impact on flight. Students work in teams to design, build and fly a simple rotor using basic materials that drops the slowest from a height of ten feet.

Lesson Objectives

- Learn about the forces that impact flight.
- Learn about engineering design, testing, and troubleshooting.
- Learn how engineering can help solve society's challenges.
- Learn about teamwork and problem solving.

Materials

- Student Resource Sheets and Worksheets
- Building materials for each team: sample templates, scissors, paperclips, ruler, tape, paper and cardboard in a range of thicknesses, foam sheets, and other materials students might use to be creative with their design (markers, crayons, stickers). Additional tools: pencil, safety scissors, and a ruler or measuring tape.

Procedure

1. For prior night homework, asks students to read the student reference sheets, and investigate the many different ways helicopters are used around the world. Have them read the NASA resource on helicopters at www.nasa.gov/audience/forstudents/5-8/features/nasa-knows/what-is-a-helicopter-58.html.
2. To introduce the lesson, ask students to consider how a helicopter flies. Discuss how wing shape and length, center of gravity, and the overall weight might impact flight.
3. Divide class into teams of 2-3 "engineers." Explain that they need to design and then build and test a simple rotor that can drop the slowest from a height of ten feet. The slower the decent, the longer the flight, and the more controlled the flight will be.
4. Student teams review a sample rotor template and create their own version to guide construction of their own rotor.
5. Teams construct their rotor using their template as a guide. Students should be encouraged to try out different weights of paper or cardboard, explore adding weight to different parts of the rotor, change the shape or length of their rotor parts, and

consider using other materials such as foam sheets. They can also decorate their rotors to add visual creativity.

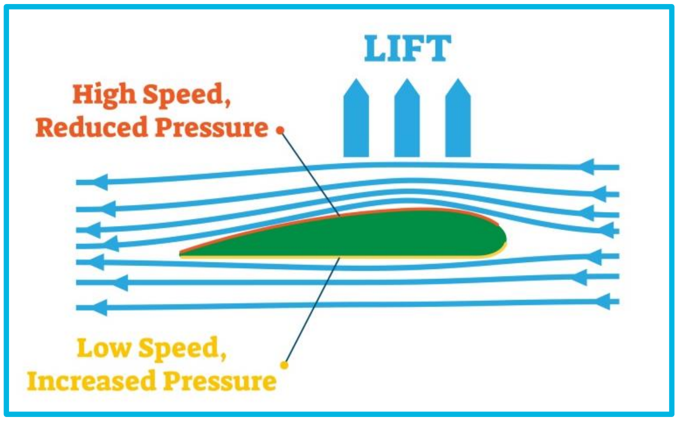
6. To flight test, the teacher or other adult should drop each rotor from a height of ten feet (stand on a chair in classroom for example). Students will measure the amount of time it takes for each copter design to reach the floor. Each rotor can be tested three times and the slowest flight of the three is used for team competition.
7. Optional Multi design or Redesign Phase. If time permits allow teams to build two designs or have the opportunity to revise or fine-tune their design based on how their initial design scored during testing. Redesign is a normal part of all engineering design processes, so this step is important for students to experience if time allows.
8. Teams complete a reflection sheet observing their designs and those of their classmates, and share their experiences with the class.

◆ Time Needed

One to two 45 minute sessions.

Student Resource:
What Forces Impact Flight?

There are four forces that impact flight: Weight, Lift, Drag, and Thrust. All four forces have to be taken into consideration when designing and building a glider or airplane. In flight, each force has an opposite force that works against it.



Everything has **weight**, which is a result of gravitational forces. The materials selected for a glider design will have a weight that will need to be offset by "Lift" in order to fly.

Lift is an aerodynamic force that helps to counteract weight. The heavier an object is, the harder it is for lift to work againt it and achieve flight. But, the forward motion (velocity) or **thrust** of an aircraft through the air along with the shape of the aircraft and its parts, especially its wings, all impact how strong the force of lift will be! Many wings have a curved shape on top and are flatter on the bottom so air moves faster over the top. When air moves faster, the pressure of the air decreases. If the pressure on the top of the wing is lower than the pressure on the bottom of the wing, the difference in pressure helps lifts the wing up into the air.

The last of the four forces impacting flight is **drag**….and this force works to slow a glider or plane. Drag is a force that acts opposite to the relative motion of any object moving with respect to surrounding air (or water!). For example, drag acts opposite to the direction of movement of a object such as a car, bicycle, airplane, glider, or boat hull. It is impacted by the shape and material selection of a plane or boat, as well as other factors, including the humidity of the air. It is also impacted by the the thrust or speed of the aircraft…the greater the thrust, the greater the drag.

In the case of the glider to be built as part of this lesson…the thrust is generated by the person who will push your plane through the air during testing! For a motorized plane, it is the motor that provides propulsion and the power to move through the air. A plane may have several motors to generate thrust, and the design of the motor also impacts how the surrounding air is moved, which in turn impacts thrust and drag.

All the forces impacting flight are interrelated. How a plane flies depends on the strength and direction of all four forces! If all are in balance, a plane will move along at a constant velocity. If there are any imbalances, the plane will move in the direction of that force…for example if weight overpowers lift, the plane will move down.

A plane goes up if the forces of lift and thrust are stronger than gravity and drag. If gravity and drag are stronger than lift and thrust, the plane goes down.

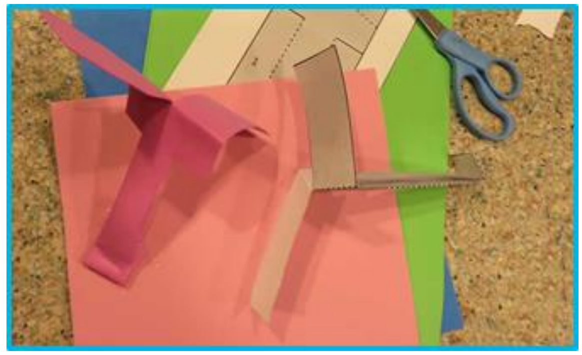
Student Worksheet:

◆ Engineering Teamwork and Planning

You are a team of engineers given the challenge of creating a rotor out of simple materials that falls as slowly as possible. You may use any materials provided to you and will first work as a team to review a sample template and develop your own design for a rotor.

◆ Planning and Design Phase

Be sure to read the summary sheet about the forces that impact flight.



Your team has been provided with a set of materials and a two sample templates for a rotor. You can try these but there may be some aspects of each design that are better. Or you may have your own ideas on how to adjust the template – make a part wider or narrower, make a cut that is longer or shorter. You will design your own rotor and try a few variations to come up with the best design.

Since your rotor has no motor, it has only one source of lift so can only fly down when it is dropped from a height. But your design can impact how slowly it falls…your challenge is to build a rotor that takes the longest to hit the ground.

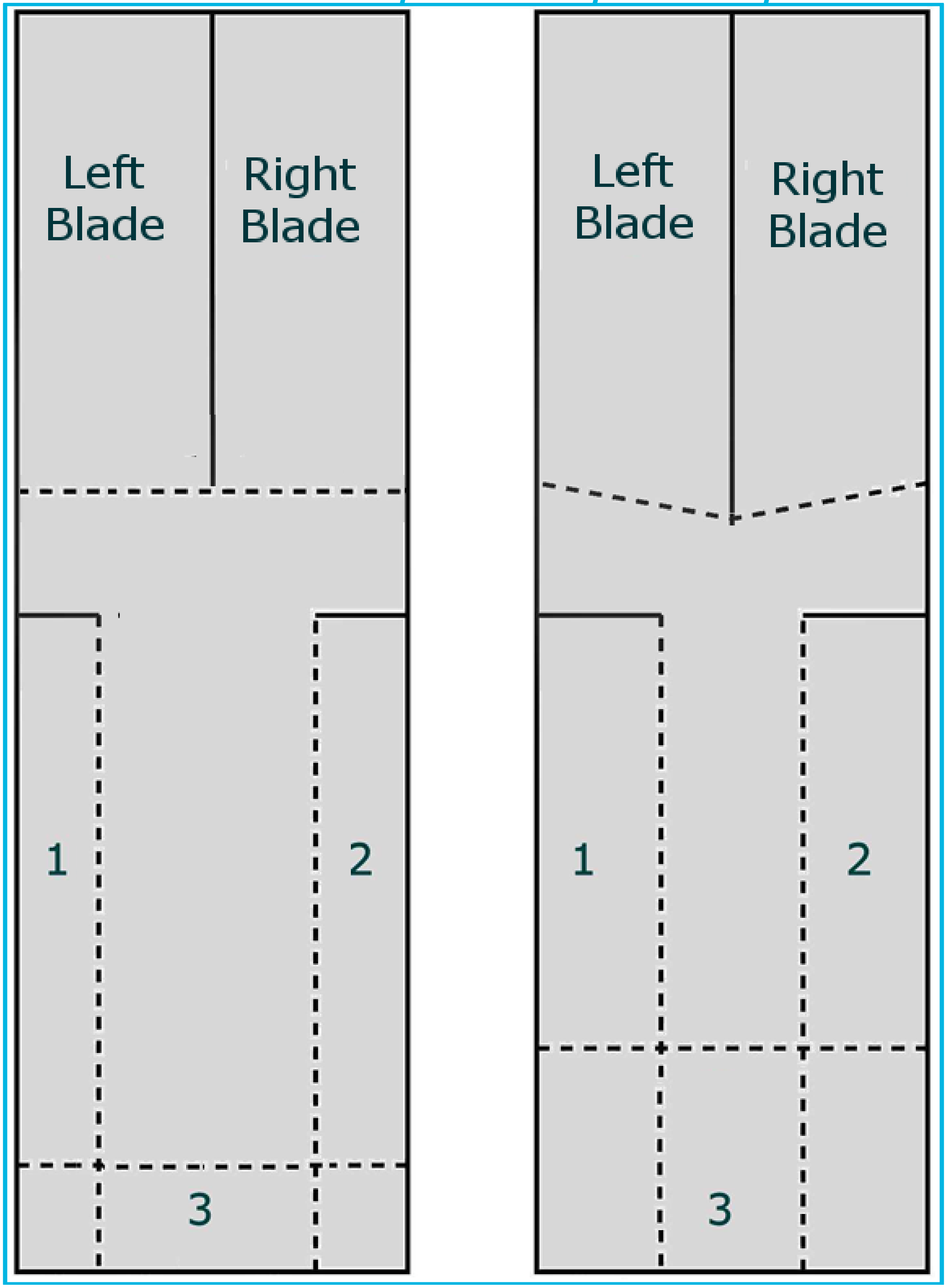
To try the basic templates, cut along the solid lines and fold along the dotted ones. Make sure your blades are folded in opposite directions. Weighting or folding the bottom will help provide structural support and lower the center of gravity of your copter. You can investigate other modifications!

Your teacher will provide a range of weights and types of materials from paper to cardboard to foam sheets. You can add other items provided as well.

As a group decide on the design of your rotor and draw a simple plan in the box below. Also include a list of materials you have selected for construction. Then draw a full size template of your parts which can be used to cut and build your actual rotor.

Materials Required for Building:

Student Worksheet: Sample Helicopter Templates



Student Worksheet:

◆ **Construction Phase**
Gather your materials, review your plan, and build your rotor. Your team can change its design in the building stage, if necessary, to improve the final result. Then, answer the questions below:

1. How similar was your final rotor to either of the original design templates?

2. If you found you needed to make changes during the construction phase, describe why your team decided to make revisions.

3. Why do you think the spinning rotor motor slows down the fall of the paper and produces lift?

4. Did you find you needed to add additional materials during construction? What did you add, and why?

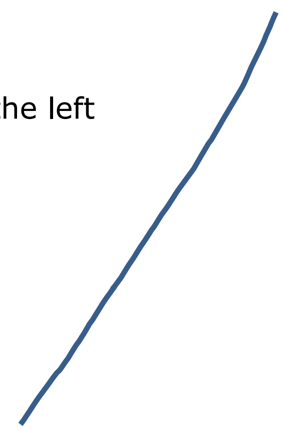
5. Do you think that engineers often change their original plans during the manufacturing phase of development? How do you think this might impact a planned design or manufacturing budget?

6. How did you decide on the shape of the parts of your rotor? What was it about the shape of each part that you thought might help your rotor fly longer?

Student Worksheet (continued):

◆ Flight Test Phase

Your teacher will test each rotor three times to maintain consistency in measuring the time it takes to reach the floor. For comparison, crumple up a piece of paper of the same thickness you used for construction and see how long it takes to drop! For your rotor, indicate the amount of time it took for each test to reach the floor.

Example: Flight Time: 4 seconds start Flight Path: Our rotor curved to the left as it dropped.  end	**Test One:** Flight Time: Flight Path:
Test Two: Distance Flown: Flight Path:	**Test Three:** Distance Flown: Flight Path:

Class Best (slowest) Flight Time:

Student Worksheet (continued):

◆ **Evaluation**
Complete the evaluation questions below:

1. What aspect(s) of the design led to the success of the rotor that flew for the longest time?

2. Describe one part of your design that you think worked the best.

3. If you had a chance to do this project again, what would your team have chosen to do differently?

4. If you could have selected some building materials which were not made available to you, what would you have selected? Why?

5. Do you think this project worked better because you were part of a team, or do you think you could have done a better job working alone?

6. Do you think that engineers work alone, or in a team when they are developing new materials, processes, or products?

7. If your rotor design was scaled up in size to be the size needed for a helicopter, do you think it would work?

8. What materials would you make a full scale helicopter rotor out of? Why?

For Teachers:
Alignment to Curriculum Standards

All lesson plans in this series are aligned to the Next Generation Science Standards, and if applicable also to the Computer Science Teachers Association K-12 Computer Science Standards, the U.S. Common Core State Standards for Mathematics, and the International Technology Education Association's Standards for Technological Literacy.

Next Generation Science Standards (grades 3-5)

Students who demonstrate understanding can:

- 3-PS2-1. Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object.
- 3-PS2-2. Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion.
- 3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
- 3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
- 3-5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.
- 5-PS2-1. Support an argument that the gravitational force exerted by Earth on objects is directed down.

U.S. Common Core State Standards for Mathematics (grades 3-5)

- Grade Three: Represent and Interpret Data (CCSS.MATH.CONTENT.3.MD.B.4)
- Grade Four: Represent and Interpret Data (CCSS.MATH.CONTENT.4.MD.B.4)
- Grade Five: Represent and Interpret Data (CCSS.MATH.CONTENT.5.MD.B.2)

International Technology Education Association's Standards for Technological Literacy (grades 3-5)

- Chapter 8 – The Attributes of Design
    - Definitions of Design
    - Requirements of Design
- Chapter 9 – Engineering Design
    - Engineering Design Process
    - Creativity and Considering all ideas
    - Models
- Chapter 10 – The Role of Troubleshooting, Research and Development, Invention, and Experimentation in Problem Solving
    - Troubleshooting
    - Invention and innovation
    - Experimentation
- Chapter 11 – Apply the Design Process
    - Collect information
    - Visualize a solution
    - Test and evaluate solutions
    - Improve a design