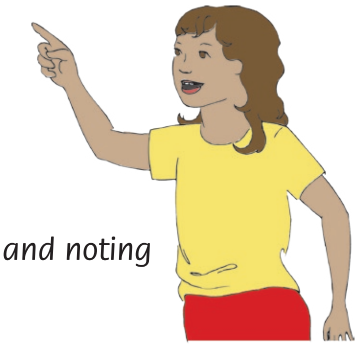
Rotorcraft Explorations 5-7

Explorations five through seven prepare students for the Rotorcraft Challenge in Exploration 8. In each of these explorations students conduct a scientific investigation and work collaboratively with their teams.

Exploration	Objectives	New Concepts	Prerequisite Concepts	Standards
Exploration 5: Rotor Blade Shape and Flight *Students investigate how a change in the shape of a rotor blade affects the amount of lift it generates.* **Exploration 6: Long and Short Rotor Blades** *Students investigate how a rotor blades' length affects the amount of lift it generates.* **Exploration 7: Rotor Blade Weight and Flight** *Students investigate how a rotor blades' weight affects its ability to generate lift.*	1) *Students will conduct investigations in rotorcraft flight using models that they construct.* 2) *Students will develop the ability to do scientific inquiry.* 3) *Students will develop an understanding of scientific inquiry.* 4) *Students will work collaboratively with a team and share their findings.*	1) *Scientific inquiry involves learning about things by doing something to the things and noting what happens.* 2) *Scientific investigations may take many different forms, including observing what things are like, what is happening somewhere, and doing experiments.*	1) *A model of a rotorcraft can be used to test how a rotorcraft flies.* 2) *The rotor blades on a rotorcraft spin and provide the force to lift the rotorcraft.* 3) *Changes in speed or direction of motion are caused by forces. The greater the force is, the greater the change in motion will be.*	**Meets**: 2061: 1B K-2 #1 2061: 1C K-2 #2 NSES: A K-4 #1, #2 **Partially meets**: 2061: 1B 3-5 #1 2061: 1C K-2 #1 2061: 4F 3-5 #1 *(Additional standards are listed in the explorations.)*

Exploration 5: Rotor Blade Shape and Flight

Students investigate how a change in the shape of rotor blades affects the amount of lift they generate.



Main Concept

People can often learn about things by doing something to the things and noting what happens.

Goal

Students will design and construct simple models and use them to conduct a scientific investigation into how the shape of a rotor blade affects the amount of lift it generates.

Objectives and Standards

Objectives	Standards
1. *Students will design and construct simple models that use rotor blades of different shapes for flight. (For example, flat vs. curved.)* 2. *Students will conduct an investigation in rotorcraft flight using the models they construct.*	**Partially Meets:** 2061: 1B (K-2) #1 2061: 1C (K-2) #2 2061: 1B (3-5) #1 NSES: A (K-4) #1, #2
3. *Students will differentiate between the flight of a model using one shape of rotor blade and the flight of a model using a different shape of rotor blade.* 4. *Students will develop the ability to do scientific inquiry.* 5. *Students will develop an understanding of scientific inquiry.* 6. *Students will work collaboratively with a team and share their findings.*	**Addresses**: 2061: 4F (3-5) #1

Prerequisite Concepts

- *A model of a rotorcraft can be used to test how a rotorcraft flies.*
- *The rotor blades on a rotorcraft spin and provide the force to lift the rotorcraft.*
- *Changes in speed or direction of motion are caused by forces. The greater the force is, the greater the change in motion will be.*

Links to Resources that Address Prerequisite Concepts

Robin Whirlybird Exploration #1: What is a Model?
Robin Whirlybird Exploration #2: How Do Rotorcraft Fly?
Robin Whirlybird Exploration #3: How Do Rotors Create Lift?
Robin Whirlybird Exploration #4: Rotorcraft Flight and Lift

Robin Whirlybird
http://rotored.arc.nasa.gov/story/robin18.html
http://rotored.arc.nasa.gov/story/robin3.html
Click on button "Rotorcraft Activities"

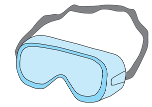
New Concepts

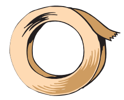
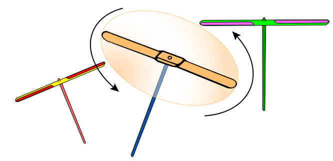
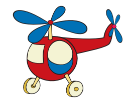
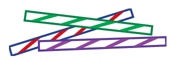
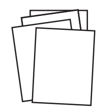
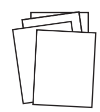
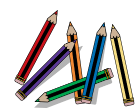
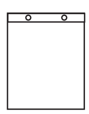
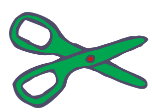
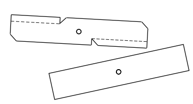
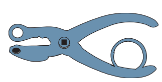
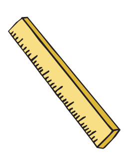
- *Scientific inquiry involves learning about things by doing something to the things and noting what happens.*
- *Scientific investigations may take many different forms, including observing what things are like, what is happening somewhere, and doing experiments.*

Schedule

Allow 2-3 sessions of 20-40 minutes.

Materials

- *Protective eyewear for each student, available from most school science supply stores and catalogs* 
- *Chalk or tape* 


- *One "flying dragonfly," which is a toy rotor that flies (shown right), for each pair of students* 
-  *A variety of lightweight and heavyweight plastic, metal and wood toy replicas of various sizes and types of helicopters available at most toy stores*
- *Sturdy drinking straws* 
- *Cardstock paper for students to use in their rotor blade construction based upon their own designs* 
- *Drawing paper and crayons or coloring pencils*   
- *Chart paper* 
- *Scissors 1 per team/pair* 
- *Propeller template in this lesson's appendix* 
- *Hole punchers 1 per team/pair* 
- *Cellophane tape roll 1 per team/pair* 
- *Rulers 1 per team/pair* 
- *Stopwatches or watch/clock with second-hand* 

- At least one Data Table (in this chapter's appendix) for each team/pair
- Evaluation rubric in this chapter's appendix

Safety Precautions

When using flying objects in a classroom, post very strict rules and review them with the students. All students MUST wear protective eyewear while any object is in flight. Clearly delineate one or more staging areas, preferably with students' input. Mark on the ground with chalk or tape, where all "test flights" will take place. Caution students to "secure the area" before beginning any "test flight."

Engage

1. Draw on students' prior knowledge by asking them about models.
   - **Question:** Why do scientists use models?
     Scientists use models so they can test how the real thing would work.

2. Tell students that today they will be scientists investigating how the shape of rotor blades affects the flight of rotorcraft.

3. **Question**: How do you think the flight of a rotorcraft will be affected if we change the shape of the rotor blades?
   List students' responses on chart paper. These responses are their hypotheses.

4. Show students some possible models from the previous explorations:
   - The "flying dragonfly" toy rotor
   - Toy helicopters that do not fly

5. *Ask students whether they could use one of these models to test their ideas.*
   - *If students suggest that they use the toy rotor, ask them how they would make adjustments to the rotors.*

   - *Students might suggest that they build a model using the commercially-made rotor as the "model for their model." This can be done using heavyweight straws and cardstock paper, but allow the students freedom to come up with their own designs and decide on their own materials for construction.*

6. *Distribute the drawing paper and crayons or coloring pencils for students' designs.*

7. *Engage students in the design process either as a whole class, in teams, or pairs.*

8. *Have each team/pair present their design to the class.*
   - *Follow up each short presentation with a brief discussion as to the design's viability. Students can choose to put all their design ideas together into one really good idea or agree to use two of the more viable designs.*

   - *Whichever design is agreed upon, this exploration could continue using the template found in this exploration's appendix. Students construct their flat and curved rotor blades from the template, cutting out the shapes, and connecting the rotor blades to straws using tape.*

9. *Once the models are constructed proceed to the next section.*

Explore

1. ***Question**: Using our model, how can we find out if there would be a difference in the way the model flies using a _______ rotor blade or a _______ rotor blade? (For example, the words "flat" and "curved" could be placed in the blanks, but use whatever shapes the students decide upon for their tests.)*

2. *Invite students to discuss and explore the answer to this question.*

3. *Working in teams or with partners:*
   - *Have students draw out step-by-step how they would set up a test to verify each rotor blade's flight.*
   - *Have students share their experiment ideas with the class.*
   - *After discussing each proposed experiment have students help each team make revisions in their experiment design by asking questions about "how it will work."*

4. *Have each team revise their experiments:*
   - *Give students time to revise their experiments.*
   - *Have the teams share their revised experiment ideas again with the class.*

5. After discussing all the proposed experiments, decide if only one test should be developed from all the good ideas or whether each team should go ahead with their own.
   Note to Teacher: The best way for students to learn the importance of the concepts involved in a "fair test" is to allow them to create their own test (regardless of its results) and then, MOST IMPORTANTLY, follow these tests with a class discussion of why the results occurred and how to make the test a fair one. Discussion is important throughout the process! Without this interaction before, during and after the process, much learning may be lost.

6. **Question**: What do you think you might find out when you conduct this test?
   Record their hypotheses on chart paper and place this next to their previous hypotheses.

7. **Question**: How can we make this a "fair test"?
   Solicit ideas and direct students' focus toward holding the model the same distance from the ground each time, testing in an area without moving air, performing the test a certain number of times and making the rotor blades rotate at the same rates (as far as possible). Have the group come to consensus on these test factors.
   Note to Teacher: What would make this a "fair test" is if both rotors are made of the same materials, are the same weight, are the same length and width, are flown under the same conditions and perhaps are carrying the same "load" (or weight).

8. Discuss safety issues. Emphasize proper observation skills and the importance of "thinking aloud." Distribute the protective eyewear.

9. Allow 10 minutes for open explorations. As you circulate through the group, record their observations, actions, ideas and questions. Monitor safety and proper use of materials.

Explain

1. Gather students' data perhaps regarding length of time each rotor flew.

2. Record the data in a table like the Data Table in this chapter's appendix. The left column of the table can be used to draw the shape of the blade, and the right column to list the length of time the rotorcraft stayed aloft.

3. Have the class decide how this data could be depicted. (For example, a bar graph, line graph or pictograph.)

4. Gather students together for a discussion. Reflect upon the questions the students raise based upon your own classroom observations during their exploration time.

5. Ask the group to draw a conclusion about the rotor's shape and its flight performance.
   Note to Teacher: In a fair test using a flat versus a curved rotor blade, the results should demonstrate that the curved rotor blade pushes down more air and generates more lift than the flat rotor blade.

6. Show students their hypothesis and compare the hypothesis with the conclusion. Ask students how their hypothesis should be changed.

Extend

1. If possible, bring a domesticated, caged bird into the classroom and ask students to observe the bird's wing as the teacher or owner gently extends it. Ask students to explain how the shape of a bird's wing could be useful to the shape of rotor blades on a rotorcraft.

2. If possible bring in a boat's propeller and/or an airplane's propeller. Pictures of a boat or airplane propeller could be used as well. Ask students how its shape might be used to design the shape of rotor blades on a rotorcraft.

3. If possible, bring in a box fan and have students examine the shape of the blades (while it is unplugged). Ask students why the company that makes the fans shaped the blades the way they did.

Evaluate

Use the evaluation form in the appendix and evaluate students on the following:

1. Rotor blade design and construction of the rotorcraft model
   Students can also use the rotor blade design in this chapter's appendix to construct their models.

2. Investigation
   - Students should carry out the investigation with a partner or a team.
   - They conduct a "fair test" and collect and record data.

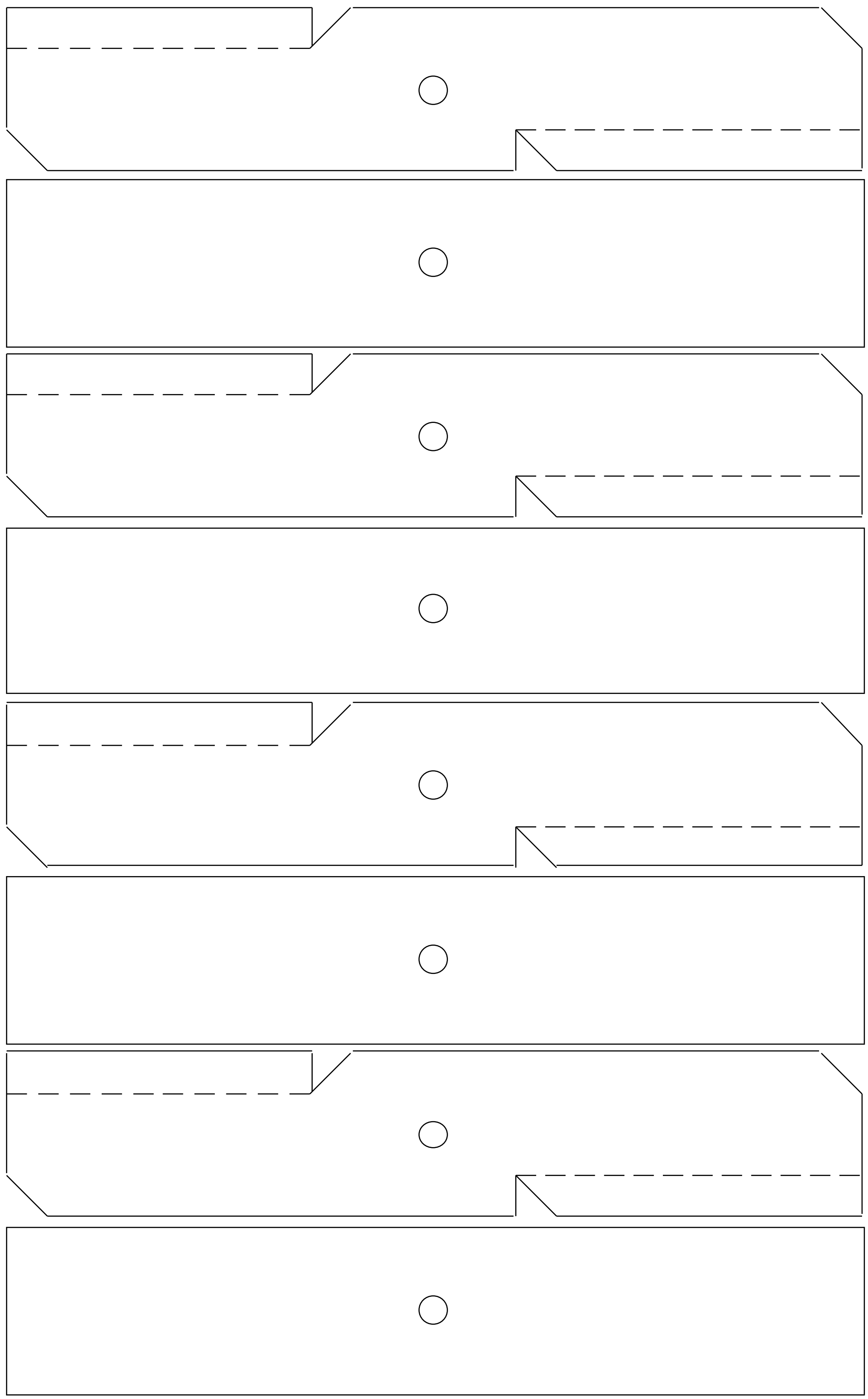
3. Reaching a conclusion
   Students reach a conclusion based on their data.

4. Revise hypothesis
   Students revise their hypothesis based on their data.

Further Exploration

An exploration could arise from a question about rotorcraft design. That is, are rotorcraft designed to perform certain tasks? If so, would the shape of the rotor blades make flight easier or harder?

Appendix: Propeller Template



Exploration 5: Rotor Blade Shape and Flight

Data Table

Team Members:

______________________________ ______________________________

______________________________ ______________________________

Use this table to record your observations. Draw or describe the rotor blade.

Rotor Blade Shape	Time

Exploration 5:
Rotor Blade Shape and Flight Rubric

Students investigate how a rotor blades' shape affects its ability to generate lift.

Evaluate students' work using the following rubric:

4	• Clear rotor blade design and construction of the rotorcraft model • Conduct a "fair test" and collect and record data • Reach a conclusion based on the data • Revise hypothesis based on data and conclusion
3	• Some attempt at rotor blade design and construction of the rotorcraft model • Attempt to conduct a "fair test" and collect and record data • Attempt to reach a conclusion based on the data • Attempt to revise hypothesis based on data and conclusion
2	• Construction of the rotorcraft model without a design • Some attempt to conduct a "fair test" and collect and record data • Reach a conclusion based on some of the data • Attempt to revise hypothesis
1	• Little or no rotor blade design and construction of the rotorcraft model • No "fair test" conducted • Conclusion not based on data • Limited revision of hypothesis