



Drexel-SDP GK-12 ACTIVITY

Science

Weather and Aeronautics

Up, Up and Away! Building a helicopter



Grade Level 6 (5 - 8)

Lesson # 5 of 10

Lesson Dependency Lessons 1 through 10 of the Weather and Aeronautics Lesson and Activity Group

Time Required: 2 Hours

Summary

In this lesson, students shift their attention from wing-based flight mechanisms to rotor-based flight. This involves using the propeller structure as a vertical lift generator: by pushing air downward, the aircraft lifts upward in accordance with Newton's Third Law. Students will see that sufficient lift must be generated to lift the aircraft by forcing sufficient amounts of air downward; this is accomplished via a high-speed launcher (a spinner) that propels the helicopter upward.

Engineering Connection

The aeronautics course is intended as a multi-disciplinary course in physics, math and history of aviation. Navigation, forces of flight, principles of flight, history of flight, and environmental factors (including weather and landforms) are specifically investigated. The core curricular items are emphasized, and aviation is considered an underlying theme. The intent is to provide grounding to the curriculum components learned in a typical K-12 school year. Aviation easily generates a lot of excitement among this age group, and as a result, measurable results are expected in these subjects.

Keywords

- Aeronautics
- Weather
- Aviation
- Flight
- Helicopter

PA Science Educational Standards

- 3.1.7A Explain the parts of a simple system and their relationship to each other.
- 3.1.7B Describe the use of models as an application of scientific or technological concepts.
- 3.2.7A Explain and apply scientific and technological knowledge.
- 3.2.7C Identify and use the elements of scientific inquiry to solve problems.
- 3.4.7C Identify and explain the principles of force and motion.

Pre-Requisite Knowledge

Principles of lift and flight demonstrated through experimentation described by the Bernoulli Lessons in this unit.

Learning Objectives

After this lesson, students should be able to:

- Identify the lifting mechanism on the helicopter.
- Construct and deploy a helicopter rotor and launcher.
- Identify the direction of motion of the helicopter, and thus identify the purpose of the counteracting tail rotor to compensate for adverse yaw.

- Describe and utilize symmetry, centripetal force, and counteracting lift from the weighted helix structure of the rotor.

Introduction / Motivation

Until now, we have looked at what are called “fixed-wing” aircraft; that is, airplanes that fly due to air passing across a wing that does not move. This is not the only way to generate lift, though. We have seen lift through buoyancy and displacement, both in the water (remember the open and closed PVC pipe?) and in the air as with hot air balloons or helium balloons. This type of flight is called lighter-than-air flight, because it is based on buoyancy of light materials in the heavier air. Airplane lift is known as heavier-than-air flight, because a heavy airplane is being suspended in light air due to Newton’s Law and Bernoulli’s Principle.

This week, we’ll explore another form of heavier-than-air lift called a rotorcraft. A common rotorcraft is a helicopter. It works by taking a wing structure and spinning it around, causing air to be forced downward. Newton’s Third Law dictates that the opposite reaction (an upward lifting force) must occur. Once this lift exceeds the aircraft’s weight, the helicopter will fly.

Materials

We will build a helicopter rotor and also a launcher to spin the helicopter into the air. The materials for each of these is as follows:

Copter:

- 2 1/2" long finish nails
- Small wooden board or short "2 by 4"
- Pliers or sturdy needle-nose pliers
- 6" long wooden tongue depressors
- Drill and 1/8" drill bit
- Hot water
- Cardboard
- Scissors, ruler
- Electrical tape
- Hot glue gun and glue sticks
- Non-hardening modeling clay
- Triple beam balance (or other way of measuring weight to nearest gram)

Launcher:

- 1" PVC pipe
- 3/8" wooden dowel, 3' long
- Drill and drill bits
- Nylon mason's twine and electrical tape
- Cereal box
- 2 1/2" long finish nails
- Hot glue gun and glue sticks, tape
- Any kind of saw

Lesson Background & Concepts for Teachers

The materials will be assembled into a rotor and a launcher per the instructions in the references. It is important, however, to keep a few things in mind along the way. First, in order to generate a downward force on both sides of the rotor, it is necessary to have the wings appear opposite one another on each end of the rotor. This way, air hitting each side of the rotor simultaneously is forced downward. The rotorcraft would roll over if symmetric lift caused air to force over one side and under the other side of the rotor. This also accounts for the helical shape of the rotor, much like a fixed airfoil: these guide the air downward on all sides. Therefore, the wings on the rotors should face away from one another. Moreover, consider the force being generated by each side of the helix. Imagine slinging a rope versus a rope with a bowling ball attached to the end. The bowling ball seems much less desirable, because of the weight of the ball. This is called centripetal force. If we can increase the force on the outsides of the rotorcraft, its own momentum will help it to spin even faster, and so doing push more air downward. This translates into a greater opposing force, and thus more lift. To accomplish this in our model, we pack clay into the outside of each side of the wing. But again, if we had more weight on one side than on another, we'd generate more lift on one side than the other – and this would result in a turning and uncontrolled aircraft. So keep it symmetric, and keep those weights and distances from center equal!

Finally, observe what happens when launching your rotorcraft. Does it launch straight or does it turn? It does indeed turn, and in which direction? It turns in the direction of the spin. The spinning momentum results in an undesired turning force. This is why we see helicopters spin in one direction in movie crash scenes. How can we counteract this?

Real helicopters have a tail rotor that also spins vertically to push the helicopter into a sort of a spin in the reverse direction of the primary rotor spin. This counteracts the undesired spin caused by the spinning rotorcraft. How much counter-spin must this tail rotor generate? It must equal exactly the undesired spin generated by the primary rotor, and this varies with the primary rotor's speed. So the tail rotor's speed is also adjustable.

Vocabulary / Definitions

Word	Definition
Rotorcraft	An aircraft that uses a non-fixed wing to generate lift. Lift is generated by the opposing upward force generated by the spinning rotor's downward thrust.
Rotor	A spinning airfoil structure.
Helix	Like a DNA strand, the rotor is shaped in a twisted shape called a helix. This twisted shape provides symmetrical and opposing downward thrust on either side of the rotor.

References

<http://www.sciencetoymaker.org/copter/assembl.html>

<http://www.sciencetoymaker.org/copter/launcher.htm>

Author

William M. Mongan

Jason Coleman

Date

12/2/2007

Copyright

Copyright 2007 Drexel University GK12 Program. Reproduction permission is granted for non-profit educational use