EAA eActivities

Band of Whirling Dervishes

Teacher Copy

Lesson Focus

This lesson focuses on the concept of "torque," which is the **twisting motion** that affects helicopters and propeller-driven airplanes. Students will construct a propeller and helicopter inspired device and test it to make their own definition of torque. This links to the four forces of flight (thrust, drag, lift, and gravity) with a particular focus on thrust.

Newton's third law of motion, which states that for every action (force) there is an equal and opposite reaction, is demonstrated through the movement of the helicopter responding to the rubber band rotations.

What is a whirling dervish?

Grade Levels

9-12

Objectives

During this lesson students will:

- Build their own helicopter (may be done with partners)
- Record observations
- Adjust design
- Communicate results

Materials

(Materials for a group of 20 students working)

1. 20 propeller assemblies
2. 20 craft sticks (1 cm x 10 cm) or balsa wood strips (1 cm x 17 cm)
3. Tape
4. Scissors
5. Piece of cardboard or construction paper to make helicopter
6. Markers to decorate the helicopter (optional)

7. Pencils or pens
8. Ruler
9. 20 rubber bands
10. 20 paper clips
11. Card stock cut into:
    a. 5 cm x 4 cm
    b. 10 cm x 8 cm
    c. 15 cm x 12 cm
    d. 20 cm x 16 cm

Pre-Lab Questions: Please use complete sentences with correct punctuation.

1. What are Newton's three laws of motion? Write them down or look them up.

   First: Objects at rest or in motion tend to stay at rest or in motion until acted upon by an outside force.

   Second: Describes how mass, acceleration, and force are related. f = ma

   Third: Every action has an equal and opposite reaction.

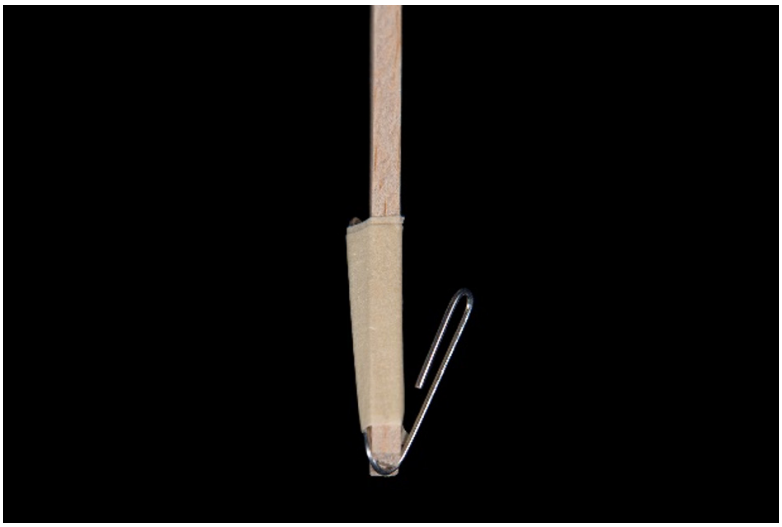
2. What is torque? Try defining and then look up a definition. *Torque is the angular or rotational equivalent to force.*
    a. What everyday items use torque? *Opening a door handle, opening a bottle cap*
    b. Theorize how torque might work with a helicopter's two rotors. *Large top rotor provides lift and thrust, and the smaller back rotor counteracts "torque" or twist of fuselage.*
    c. So how does your definition apply in this instance?
    d. Can you revise your definition to be more accurate?
    e. Which of Newton's laws most applies in this case? *Third* and why? *The rotation of the large top rotor causes the fuselage to want to turn in the opposite direction because of torque. The smaller rotor helps to counteract the torque effect.*
3. Which way do you think propellers rotate on a propeller-driven airplane? Why? *Counterclockwise/to be uniform.*
4. If the propellers rotate this way, what does this make the airplane want to do? *Rotate clockwise or left wing down.*

5. Airplane pilots use ailerons to counteract the rolling motion. Look up the term aileron and find an illustration where you can see one. Draw it here.

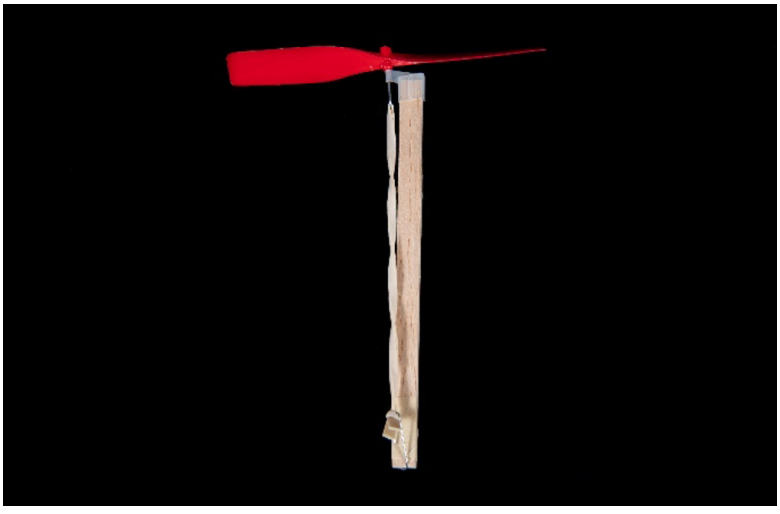
Part 1

Procedure

1. Fit the plastic cap onto the end of the craft stick to attach propeller.
2. Open the paper clip slightly and wrap around the other end of the craft stick.



3. Tape it securely.
4. Stretch a rubber band between the hook on the propeller and the paper clip.
5. Cut and retie the rubber band to provide a taut fit.



In a helicopter, the tail rotor would be used to counteract torque. Because the helicopter you are building is so light, you will be using air resistance to counteract the effects of torque. If the force of torque is left unbalanced, the rotor and the craft stick will both turn, in opposite directions (Newton's third law), and use up much of its energy. If we can counteract the torque effect, your helicopter will fly much higher!

6. Wind the propeller about 20 times, and without letting go of the helicopter, let the propeller go. Note which way the air is blowing.
7. Now wind the propeller in the other direction about 20 times, and check the air direction again. For the rest of the experiment, make sure to turn the propeller in the direction that pushes the air down.
8. Without attaching a card to the helicopter, turn the propeller 35 times, and let it go. Write down your observations. Repeat two more times.
9. Test each size card stock by attaching it to the craft stick, turning the propeller 35 times and making observations. Test each size three times.

Circle the terms that show your hypothesis and fill in the blank.

Hypothesis: I think the helicopter will fly (higher or lower) when I add a (larger or smaller) piece of card stock because _____

_____

_____

_____

Data

Sample Data Table: Helicopter Trials

Independent variable: the variable that is changed.
Dependent variable: the variable being measured due to the independent variable.

Trial	Card Size	Observations
1	None	
2	None	
3	None	
4	5 cm x 4 cm	
5	5 cm x 4 cm	
6	5 cm x 4 cm	
7	10 cm x 8 cm	
8	10 cm x 8 cm	
9	10 cm x 8 cm	
10	15 cm x 12 cm	
11	15 cm x 12 cm	
12	15 cm x 12 cm	
13	20 cm x 16 cm	
14	20 cm x 16 cm	
15	20 cm x 16 cm	

Was your hypothesis supported? Why or why not?

Part 2

Use the data you collected in Part 1 to re-engineer your helicopter to fly between 1.5 and 2 meters off the ground.

1. What is your dependent variable?

   Height of flight

2. What are two possible independent variables?

   Size of card stock and number of turns of the propeller

Sketch your design below. Indicate the size of your card stock and how many times you will turn the propeller.

Test your design at least three times.

Trial	Card stock size	Number of turns	Height

Modify

You may choose one of your independent variables to change to see if you can get closer to the goal of 1.5 to 2 meters off the ground.

Test your design at least three times.

Trial	Card stock size	Number of turns	Height

Analysis Questions

1. What worked well with your design?
2. What other factors would you change if you could?
3. How does the helicopter use torque to provide flight? Think about what your model did.

   The turning of the propeller with force provides the lift and thrust.
4. What do you think the smaller back rotor on a helicopter does? *It counteracts the effects of torque.*
5. What would your model need to fly straight ahead? *A second rotor or another way to counteract the torque.*

Extension

Look at the evolution of the modern-day helicopter. Use a variety of sources, including print and digital. What uses and design changes do you think it could evolve from its present form?

Alignment to Curriculum Frameworks

NGSS Engineering Practices

- Apply scientific ideas to solve a design problem, taking into account possible unanticipated effects.
- Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: Decide on types, how much, and accuracy of data needed to produce reliable measurements; consider limitations on the precision of the data (e.g., number of trials, cost, risk, time); and refine the design accordingly.

Common Core State Standards – ELA

- **WHST.9-12.7.** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
- **WHST.11-12.8.** Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.
- **WHST.9-12.9.** Draw evidence from informational texts to support analysis, reflection, and research.