Tumblewing Gliders

Teacher Copy

EAA eActivities

Lesson Focus

This lesson focuses on Newton's laws of motion and Bernoulli's principle. It also touches on the four forces of flight (thrust, drag, lift, and gravity) and how changes in design can affect performance.

Grade Levels

6-12

Objectives

During this lesson students will:

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

Keywords

Keywords will depend on the focus of your lesson review, or have students review the following.

Axis: *An imaginary line around which a body rotates.*

Thrust: *The force that moves an aircraft through the air.*

Drag: *The force that resists movement through the air, air resistance.*

Lift: *The force that directly opposes the weight of an airplane and holds the airplane in the air.*

Gravity: *The force that holds all objects to the Earth.*

Bernoulli's principle: *Within a flow of fluid (or air), points of higher fluid speed will have less pressure than points of slower fluid speed. The higher-pressure areas will want to move to the lower-pressure areas.*

Newton's laws of motion:

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.

How Does a Tumblewing Work?

A tumblewing, like any object that flies, uses the four forces of flight. The four forces of flight are **lift, thrust, gravity,** and **drag.** Lift must overcome gravity and thrust must overcome drag for an object to stay airborne. You will notice that if you just drop your tumblewing, it will slowly fall to the floor, spinning around its axis, because the force of gravity is stronger than the tumblewing's lift; this is called **stalling.** But, if you walk behind it with a piece of cardboard to create a ridge of air for the tumblewing to ride on (called a ridge lift), the air provides both the upward lift and the forward thrust. With these two forces balanced, the tumblewing can fly forward.

Materials for Each Group

1. Template for tracing wing
2. Pencil
3. Scissors
4. Tracing or similar lightweight paper
5. Sheet of cardboard, 30 cm by 30 cm minimum

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

1. What part of an airplane usually provides the lift? *Wings*
2. What part of an airplane usually provides the thrust? *Jet engine or propellers*
3. After reading how a tumblewing works, explain in your own words how lift and thrust will be provided to the tumblewing.

Procedure

Building

1. Trace the template onto the tracing paper.
2. Cut out the wing.
3. Fold the ends of the wing up at 90 degrees.
4. Bend the leading edge up slightly.
5. Bend the trailing edge down slightly.

Flying

1. Hold the cardboard at 30 degrees with the top closest to you.
2. Release the wing over your head and walk towards the wing, keeping it aloft.

After flying the template model to get the hang of it, record your best distance. Discuss some modifications you might make to the design. See if you can increase the flying distance.

Students can change the type of paper, the size of the folds, or modify the length and width.

Independent Variable:_______*What the student is changing, paper type or size?* ________________

Dependent Variable:________ *Distance flown* ____

Hypothesis: By changing the______________________________ to ___________________________

on the tumblewing, the tumblewing will fly farther, because _________________________________

____.

Test your new design at least three times. Then try another change.

Data

Sample Data Table Best flight with template wing ______________________________

Trial	What did you vary?	What did you vary?	What did you vary?
Distance Traveled, m			
1			
2			
3			
4			
5			

Present your conclusion to your peers. What was the best flight you had and why based on your data. If you had more time and unlimited materials, what would you test next?

Questions

1. How does Bernoulli's principle figure into this lab?

2. Why did one wing type work better than another?

Alignment to Curriculum Frameworks

Next Generation Science Standards Grades MS

NGSS Engineering Practices

- **MS-PS2-2.** Plan an investigation individually and collaboratively, and in the design: Identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how much data is needed to support a claim.
- **MS-PS2-5.** Conduct an investigation and evaluate the experimental design to produce data to serve as the basis for evidence that can meet the goals of the investigation.
- **MS-ETS1-2.** Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
- Apply scientific ideas to solve a design problem, taking into account possible unanticipated effects.

Common Core – ELA

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

Assessment

1. According to Bernoulli's principle, is air going to go over or under the wing faster?
   - **a. Over**
   - b. Under
   - c. Both are equal speed
2. According to Bernoulli's principle, fast air equals
   - **a. Low pressure or lift**
   - b. High pressure or lift
   - c. Low pressure or drag
   - d. High pressure or drag
3. Weight is the same as gravity
   - a. True
   - **b. False**
   - c. The two are not related

4. What function do the upturned flaps on the short ends of the wing perform?
    a. Lift
    b. Thrust
    c. Stability
    d. Drag
5. Accelerating flight is achieved where
    a. Gravity + drag < lift + thrust
    b. Gravity + lift < drag + thrust
    c. Drag + lift < gravity + thrust
    d. Drag + thrust < gravity + lift
6. What is drag caused by?
    a. Lift
    b. Gravity
    c. Thrust
    d. Friction
7. When your wing falls to the ground it is called
    a. Flying
    b. Dragging
    c. Stalling
    d. Circling
8. The large sheet of cardboard provides
    a. Gravity
    b. Flexibility
    c. Lift and thrust
    d. Drag against gravity