Flying Cups

Teacher Copy

Lesson Focus

This lesson focuses on Newton's laws 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 Level

6-12

Objectives

During this lesson students will:

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

Keywords

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

Magnus effect: *The Magnus effect occurs when a moving spherical or cylindrical body has a spin. The observed effect is that the moving, spinning body moves away from the intended direction of travel.*

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 (including 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.

Magnus effect video

Materials for Each Group

1. Two cups (plastic or foam are best, but paper will work); try to provide different sizes to test
2. Tape
3. About 10 rubber bands

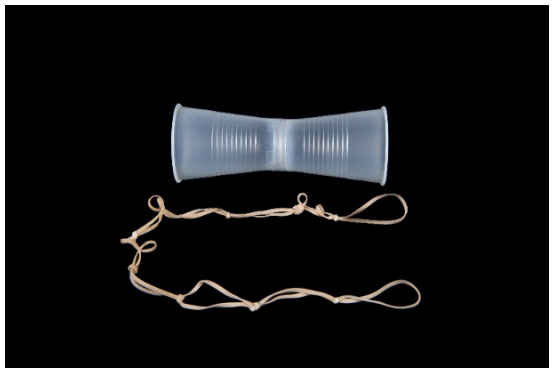
Pre-Lab Questions: Please use complete sentences with correct punctuation.

1. What are Newton's three laws of motion? *See above.*
2. Read over the lab. Which law do you think applies and why? *Newton's third law.*
3. How do you think Bernoulli's principle will affect aircraft? *Bernoulli's principle shows how as faster-moving air is moving across the top of a wing, and slower air is moving under the wing, the higher-pressure area under the wing pushes to the lower-pressure area above the wing and pushes the wing up, pushing the aircraft up.*

Procedure

Building

1. Hold two cups of the same size bottom to bottom.
2. Tape them together.
3. Make a chain out of rubber bands.
4. Wrap the chain around the middle of the cups at the taped area.



Flying

1. Hold tension on the rubber band.
2. Position the rubber band so that it comes out from the bottom of the cups.
3. Release the tension and let the cups fly.

After flying the cups 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. Or, if possible, get another size of cups to compare distance traveled.

How will you modify your design? Draw your modifications here:

Hypothesis: Circle your choice. By (increasing/decreasing) the diameter of the cup, the distance flown by the cups will (increase/decrease), because

Create a data table to keep track of your trials.

Data

Example: Changing the diameter of the cups

Trial	Diameter of rim, cm	Distance flown, cm
1	7 cm	
2	7 cm	
3	7 cm	
4	10 cm	
5	10 cm	
6	10 cm	

Present your conclusion to your peers.

My hypothesis was supported/not supported. The data showed that_____

_____. If this experiment were repeated, I would try _____

_____.

Analysis Questions

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

2. Did one cup size work better than another?

3. The Magnus effect is when something spins perpendicular to movement, like in this lab. Airplanes and large ships have been created using the principles in this lab. How would you create an airplane around the Magnus effect? Draw it out.

Alignment to Curriculum Frameworks

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 cups 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. The Magnus effect is
   - a. When an object spins perpendicular to the direction of movement
   - b. An unusual ship propulsion
   - c. An unusual way to power an airplane
   - **d. All of the above**

5. What function do the upturned flaps on the short ends of the wing perform?
   - a. Lift
   - b. Thrust
   - **c. Stability**
   - d. Drag

6. Why isn't the Magnus effect used to power aircraft today?
   a. The rollers are too expensive to make
   b. There's no brake on the rollers so you can't stop
   c. They are dependent on wind to move
   d. The rollers have to be too big to move an airplane

7. Climbing, accelerated flight is achieved where
   a. Gravity + drag < lift + thrust
   b. Gravity + lift < drag + thrust
   c. Drag + lift < gravity + thrust
   d. Drag + thrust < gravity + lift

8. What is drag caused by?
   a. Lift
   b. Gravity
   c. Thrust
   d. Friction

9. When your cups fall to the ground it is called
   a. Flying
   b. Dragging
   c. Stalling
   d. Circling

10. The rubber band assembly provides
   a. Gravity
   b. Flexibility
   c. Thrust
   d. Drag against gravity