Balloon Bust

Leader Notes

Design a way to keep a water balloon from bursting when dropped from a height of 25 feet.

Time
1 to 2 Hours

Careers
Industrial & Manufacturing
Materials Science

Topic
Forces, Motion & Energy
Technology & Materials

Grades
3–5, 6–8

Background

Engineers develop and test different types of materials, designing a range of products to solve common problems. Sometimes engineers look for ways to streamline a product so that it has less air resistance, or drag, and moves faster or more efficiently. In other cases, their goal is to increase air resistance, or create drag, to intentionally slow an object. In this challenge, students will explore different materials and the concept of air resistance as they try to prevent a water balloon from bursting upon contact with the ground.

How to Use This Activity

1. Review the Leader Notes, Student Instructions, and Challenge Video. Then decide how to group students to complete the activity. This challenge is great fun for students working in pairs, if possible. They can collaborate, discuss their design, and enjoy testing together.
2. Make copies of the Student Instructions so that each student has their own copy to reference during the whole-group activity.
3. Gather the materials and decide how you'll distribute them to the group. Consider setting up a materials table in an accessible area of the room where students can take what they need.
4. Fully fill water balloons and store them in a large container. Try to fill each balloon with the same amount of water to create consistent testing conditions. Each pair of students

Materials

Per pair:
- Masking tape
- Scissors
- String or yarn
- Water balloons (2), fully filled (distribute the filled balloons when you arrive at the drop location)
- (Optional) Mobile device for video recording (can be shared across the whole group)

In addition, provide a variety of materials for students to explore. You can also have them consider the challenge ahead of time and bring materials from home. Feel free to use what you have on hand, but some possibilities include:
- Air pillows or bubble wrap
- Cardboard boxes, small
- Coffee filters
- Craft sticks
- Egg cartons
- Newspaper
- Packing peanuts
- Paper bags
- Pipe cleaners
- Plastic bags (different sizes and weights)
- Plastic containers
- Straws

will need two water balloons for two rounds of testing (be sure to have extras on hand in case some burst unexpectedly).

5. Consider the logistics of testing.
    - Scout a location for the balloon drop that is about 25 feet high, such as a second-story window or balcony. If possible, use caution cones to mark off the area below so that spectators or passersby aren't struck by falling water balloons.
    - Consider recruiting an adult volunteer to monitor the second story drop location. The volunteer can monitor the window or balcony while you remain on the ground to manage students and the drop zone.
    - If the drop location is not proximate to the space where students will be designing, wait until all students complete their initial designs and then bring them to the drop location as a whole group.

Success Criteria

- The water balloon remains intact after falling from a specified height.

Engineering Constraints

- The balloon must be completely filled with water.
- The water balloon must be dropped from a height of approximately 25 feet (i.e., dropped from a second-story window or balcony).
- The water balloon must be dropped onto a hard surface (i.e., concrete, asphalt, sidewalk).

Instructions

Introduce the Challenge

1. Hold up a water balloon and ask questions to activate students' prior knowledge and build excitement around the challenge, such as:
    - What would happen to this water balloon if I dropped it from the second story of a building?
    - Is there anything you could do to prevent it from bursting? What ideas do you have?
    - What is gravity? How does gravity act on this balloon?
    - What do you know about air resistance or drag?

2. If needed, define force as a push or pull on an object that changes the object's direction, speed, and even its shape (if the force is strong enough).

3. Explain that gravity is a force that pulls the balloon toward the ground. When the balloon is dropped, it accelerates, or speeds up, as it falls. When it hits the ground, the balloon bursts.

4. Explain that air resistance, or drag, is another type of force—between the balloon and the air. As the balloon falls, it hits invisible air particles. The air particles create friction and slow the balloon down.

5. Tell students that they can use the idea of air resistance in their designs. When they brainstorm ideas, they can consider and test which materials have a lot of drag.

6. Share the success criteria and engineering constraints. Then show the Challenge Video for inspiration and as a preview to the activity.

Brainstorm Solutions

1. Point out the materials that students can use to build their prototypes. Explain that examining materials can inspire new ideas.

2. Have students work in pairs to brainstorm ideas and sketch their designs. Encourage them to consider the properties of the different materials and how they might be used to prevent the balloon from bursting.

3. Remind students of the design constraints and success criterion.

Build, Test, Redesign

1. Give students time to build their prototypes. If needed, define prototype as a model or something you build that shows your idea.

2. As they work, circulate and provide support and reteaching as needed. To encourage students to think more deeply about the challenge, ask guiding questions such as:
   - What materials are you planning to use? What are the benefits of using these materials? How can they improve your design?

- Explain your design. How can you prevent the balloon from bursting when it hits the ground?
- Think about drag. Which part of your design creates drag? Is there a way to increase the amount of drag?

3. When all pairs have an initial design to test, bring the group to the drop location. Distribute one water balloon to each pair. Send students in pairs to the second-story window or balcony while the rest of the group watches from below. Make sure spectators are away from the drop zone.

4. (Optional) If mobile devices are available, students may enjoy narrating and creating videos of their balloon drops.

5. After all students have dropped their balloons, return to the workspace so pairs can redesign. Tell students that they'll have one more opportunity to meet the success criterion. Give them 10 to 15 minutes to redesign and build. If students were successful on their first attempt, challenge them to make changes to their prototypes and predict how the changes will affect their results.

6. Return to the drop location and let students retest their designs.

Reflect

1. Bring students together to discuss and share. Ask questions such as:
   - What did you think of the challenge?
   - What surprised you?
   - Which parts of your prototype worked well? Which parts need improvement?
   - Are there materials that you wish you had to work with? What are they? How would you use them?
   - Who would like to share their prototype and explain how it worked in the challenge? (Encourage students to use scientific terminology in their explanations, such as force, gravity, acceleration, air resistance, or drag.)

2. Read the success criterion aloud and have students raise their hands if they achieved it.

Engineering & Science Connections

- Scientists and engineers study air resistance in order to make things work more efficiently. They design trains, cars, airplanes, and sporting equipment to reduce drag. Consider a high-speed train. The faster the train moves, the more air resistance it experiences. However, the front and sides of the train are sleek and streamlined, which causes less friction with air particles and therefore less drag. This enables high-speed trains to travel up to 200 miles per hour!
- The same principles are used when sports engineers design new clothing or equipment. They might consider materials or fabric that creates less drag, like aerodynamic skin suits, helmets, and bicycle components. All of these small improvements increase an athlete's ability to perform, even if only for recreation!
- Sometimes engineers and scientists need to increase or create drag. A parachute and a hang glider are examples where air resistance is necessary. Can you think of others?

Clothing, gear, and athletic equipment are designed to reduce drag for athletes.

Photo by Pixabay

In 1964, Japan introduced "bullet trains," named for their shape and speed.

Photo by David Dibert on Pexels

Parachuters use air resistance to counter the pull of gravity.

Photo by Daniel Reche on Pexels

Extensions

- Scout a new drop spot that is higher than the original spot. Ask students to make a prediction about how their prototype will perform at the new height. Test it and see how the results compare to the predictions.
- Have students explore parachutes. Create constraints that limit variables, such as requiring all parachutes to be made from the same material so that students can explore variations in size and shape. Distribute the same object (e.g., an action figure or several metal washers) to each pair and have them design a parachute that stays in the air for as long as possible when dropped from a second-story window or balcony. Use a stopwatch to time each pair's drop and have a contest!

NGSS Standards

Grades 3–5

3-PS21-1 Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object.

4-PS3-3 Ask questions and predict outcomes about the changes in energy that occur when objects collide.

3-5-ETS1-1 Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

3-5-ETS1-2 Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

3-5-ETS1-3 Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

Grades 6–8

MS-ETS1-1 Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

MS-ETS1-2 Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

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