National Aeronautics and Space Administration

science & sports

Educational Product	
Educators and Students	Grades 5-8

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Author
Gregory L. Vogt, Ed.D.

Editors
C. Lacy Thompson

Graphics
Angela Lane

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National Content Standards

1. National Research Council
2. National Council of Teachers of Mathematics
3. International Technology and Engineering Education Association

	Hovering on a Cushion of Air	Center of All Things	Let's Do the Twist	Crazy Balloons	Javelin Rockets	Space Helmet Challenge
SCIENCE STANDARDS[1]						
Physical Science						
Motions and Forces						
• Understand motions and the forces that cause motion	⚽	⚽	⚽	⚽	⚽	⚽
Transfer of Energy						
• Understand ways in which energy is transferred	⚽		⚽	⚽	⚽	⚽
• Understand the relationship between energy and force						
Science and Technology						
• Abilities of Technological Design	⚽			⚽	⚽	⚽
• Design a solution to a problem and evaluate its effectiveness						
MATHEMATICS STANDARDS[2]						
Number and Operations						
• Perform operations with multi-digit whole numbers and with decimals to the hundredths	⚽				⚽	
Algebra						
• Write and interpret numerical expressions	⚽					
• Analyze patterns and relationships						
Geometry						
• Graph points on the coordinate plane to solve real-world and mathematical problems	⚽	⚽	⚽	⚽	⚽	⚽
• Classify two-dimensional figures into categories based on their properties						
• Solve real-world and mathematical problems involving area, surface area, and volume						
Measurement						
• Represent and interpret data	⚽	⚽	⚽		⚽	⚽
TECHNOLOGY STANDARDS[3]						
Design						
Standard 8. Students will develop an understanding of the attributes of design.	⚽			⚽	⚽	⚽
Standard 9. Students will develop an understanding of engineering design.	⚽			⚽	⚽	⚽
Standard 10. Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.	⚽			⚽	⚽	⚽

I Do the Shimmy When I Fly Through the Air Part Three

Post-Game Wrap-up Show

What do snowboarding, figure skating, and gymnastics have to do with space? Astronauts inside the International Space Station can perform the same aerials and spins with one big exception. Astronauts do not have to stop their aerials. Because of microgravity, they don't have to land snowboards and rebuild momentum for more aerial tricks. They can keep going and going until they bump a wall or another astronaut, or until someone at Mission Control on Earth radios, "Alright, we're impressed. Get back to work."

In space, aerials work like this. You move to the middle of one of the ISS modules so you are not touching anything. You may need help to do this because drifting is common. Then, you start twisting, waving your arms, and kicking your legs. Away you go. Like the snowboarder, stop the flailing and you stop the maneuvers. Guess what? You are still in the same place inside the module. In all that movement, you failed to do one thing. You didn't exert a force on anything. To change your place, you need to apply Newton's Third Law of Motion (action/reaction).

Astronaut Peggy Whitson using Newton's Third Law of Motion to fly through the Destiny module on the ISS.

Edward H. White, Jr. on 1965 spacewalk. The gas propulsion gun in his right hand.

To get around the ISS, astronauts push against the walls, floor, or ceiling to create an action force. Their bodies respond with an equal reaction force in the opposite direction. Because of center of mass, it takes a little practice for new astronauts to do this right. If you don't push in a straight line with your center of mass, instead of going where you want to, you will rotate around the center with a few head bumps and feet in the faces of your fellow astronauts. (By the way, this can start great spins that can go on for minutes or until you get queasy.)

On spacewalks, moving is trickier. One of the first astronauts to discover this was Edward White, Jr. during the Gemini 4 mission in 1965. White carried a small gas gun on his spacewalk. He was attached to the spacecraft with a long tether and oxygen line. When he drifted away from the capsule, he had nothing to push on to get back. He could, of course, tug on the tether to get back but NASA wanted him to try the gas gun. The gun had three nozzles and by pulling a trigger, jets of gas

propelled him from one end of the tether line to the other. He exerted an action/reaction force with the gas jets.

Today, spacewalkers still have gas jets to propel themselves. The jets are attached to their backpacks and only used if they get loose from the station. The jets can push them back to safety. Most of the time, they move about by grasping handles (handholds) attached to the outside of space structures. They pull themselves from handhold to handhold to move about. Newton's laws are still at work. They pull on a handhold (action) and their bodies move (reaction).

Back to Ed White's spacewalk. White quickly found out that his gas gun was tricky to use. If he wasn't careful, just pointing the gun and firing some gas would cause him to tumble. The secret was to hold the gun in direct line with his center of mass. Then, he could travel in the desired direction.

Find out about the flight challenges of center of mass by making and testing a "crazy balloon."

Crazy Balloons

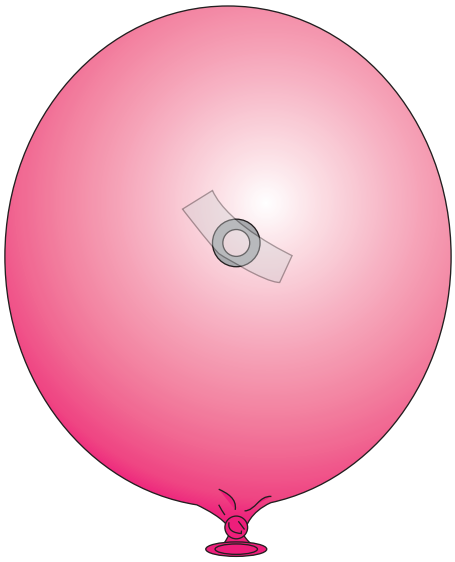
Objectives:
Students will:
- manipulate the center of mass of an inflated balloon by taping 1-3 metal washers on its outside
- create and play simulated microgravity sports with a crazy balloon

Preparation:
Obtain uninflated latex balloons. Helium-quality balloons are the most rugged.

Materials:
- Nine-inch helium quality balloons availble at party goods stores (two for every group of two or three students)
- Three metal washers (1/2 or 5/8 inch flat)
- Cellophane tape
- Balloon pumps (optional)

Management Tips:
Organize students into teams of two or three. Give each team one balloon. Caution them to be careful with their balloons because they get only one spare. While balloon pumps are optional, they make blowing up the balloon easier and more sanitary. Check the washers to make sure there aren't any burrs or sharp edges that could puncture the balloon. Encourage students to attach and test one washer at a time until they achieve an interesting flight.

Procedure: Crazy Balloon Sports
1. Have students blow up and tie their balloons.
2. Using tape, have students affix one washer to the outside of their balloons at a random location.
3. Test fly the balloons by gently slapping them upward with an open hand. Watch how the balloon flies.
4. Add up to two additional washers and test fly again. The second and third washers can be in the same or different places.
5. In a class discussion, have students propose a sport to be played with the crazy balloons.
6. By class vote, pick one of the sport ideas and play it in the classroom, using rules students create.



In case students need a little prodding, you might drop hints about sports that could work in the classroom. Here are a couple of ideas:
- A string stretched from side to side across the room and above head level, could serve as the net for crazy balloon volleyball. Clear the floor and have teams sit on the floor to play the game.
- Have students sit on the floor in two parallel lines and conduct a relay race where each student in the line must tap the balloon to the next until it reaches the last person.

Assessment:

Collect student sheets.

Have students write short paragraphs describing the flight of their crazy balloon and explaining its aerial antics. Hold a class discussion to compare descriptions and explanations.

Discussion Questions:

Why does an inflated balloon fall more slowly to the floor than an uninflated balloon?

While the addition of air inside the balloon increases the balloon's mass by a few grams, its increased diameter causes it to be more affected by air resistance than a smaller uninflated balloon. As the balloon falls, air has to move out of the way. The inflated balloon has to push more air out of the way and encounters more force than an uninflated balloon with washers attached. The inflated balloon thus falls more slowly. In microgravity, balloons won't fall to the floor; these balloons will. Tapping the balloons will cause them to float across the inside of the space station. Air resistance and the placement of washers still cause erratic flights.

Why does the weighted balloon fall with crazy maneuvers?

Placing one or more washers on the outside of the balloon moves the balloon's center of mass from the very center of the balloon (without washers attached) to one of its sides. When falling, air resistance affects the unweighted side more than the weighted side. The balloon turns so that the heavy side is downward.

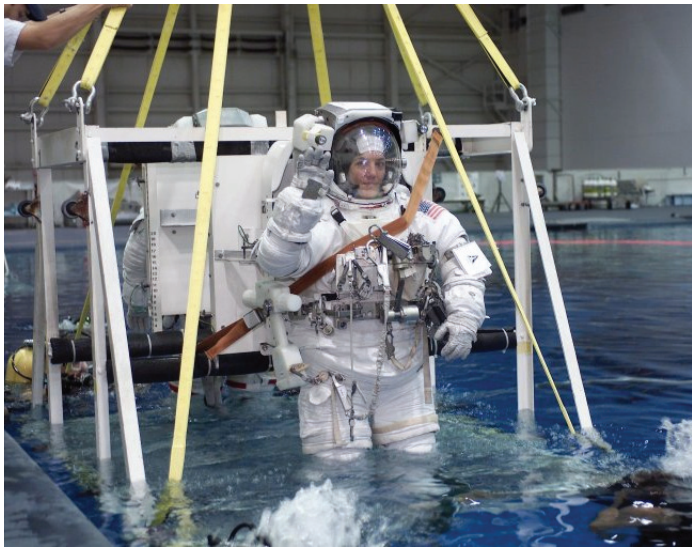
How many washers on the balloon create the craziest flights? Explain.

Just one washer produces the craziest flights. Two or three washers will make the balloon fall faster and turn the balloon faster so that the heavy side is down and the balloon falls straight.

Extensions:

- Obtain helium-filled balloons for each team. Attach strings to each balloon and have students anchor them to their tables. Challenge the teams to create a neutrally buoyant helium balloon. Neutrally buoyant means that the balloon neither rises to the ceiling or falls to the floor. Instead, it floats at the same elevation. Provide tape and weights, such as small paperclips, plastic straws, file cards, etc. When the balloons have been weighted to achieve neutral buoyancy, hold a floating contest. Release the strings and see which balloon stays aloft the longest without touching the ceiling or floor.

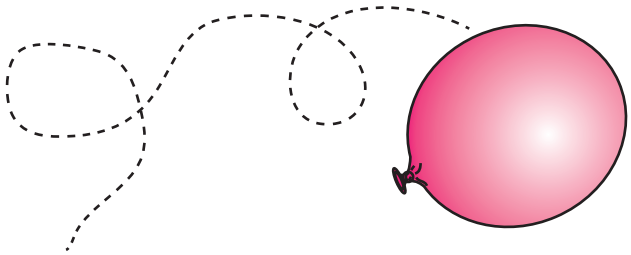
  Adding weights to the balloons is similar to what NASA engineers do when helping astronauts train for spacewalks. The astronaut dons a spacesuit, and weights are added around the outside. Then, the astronaut is immersed in a giant water tank. If the weights are placed correctly about the astronaut's center of mass, the astronaut will neither sink nor rise in the water (neutrally buoyant) and will float right side up or down, allowing the astronaut to simulate microgravity.



Astronaut Heidemarie Piper is lowered into the neutral buoyancy pool for training at Johnson Space Center. Neutral buoyancy is a useful way of simulating microgravity for astronaut training.

Crazy Balloon Championship **Name:** _____

Welcome to the first annual Crazy Balloon Championship! Pick your team and get ready to compete. First, you have to design your crazy balloon and create a sporting event to go with it.



Instructions:

1. Inflate and tie a round balloon.
2. Using cellophane tape, attach a single metal washer to the outside of the balloon.
3. Test fly your crazy balloon by giving it an upward pat and see what it does. Describe its flight.

Why did the balloon fly that way?

4. Add another washer and fly it again. What did it do?

5. Add one more washer and test it again. What did it do?

6. Select the best flight characteristics of your crazy balloon. It might fly best with just one or two washers.

7. With your teammates, invent a sport to play with your crazy balloon. What is the objective of your sport? What are the rules? Develop a presentation you can make to your class explaining your sport. The class will decide which sport is the best and try it out! (Use the back of this sheet if you need more space.)

Name of your sport _____

Rules: