Young Scientist Lab

Classroom Activity | Grades 6-8

The Everyday Science of Sports

GUIDING QUESTION

How have sports equipment evolved and advanced over the years?

LEARNING OBJECTIVES

Students will be able to:

- apply concepts of aerodynamics, drag, air friction, and bounce to golf ball design.
- learn how physics and engineering impact safety and performance related to sports equipment.
- research how a piece of sporting equipment's design has evolved since it was invented.
- use specific concepts to propose an improved design or material for a piece of sporting equipment.

OVERVIEW

In this lesson, students will learn about the science behind golf ball design and the physics of aerodynamics related to golf balls. They will work in teams to evaluate the design of several golf balls and determine how design can impact a ball's spin, accuracy, trajectory, and distance. Finally, they will apply design and engineering concepts to improve a piece of sports equipment.

NEXT GENERATION SCIENCE STANDARDS

- PS2.A: Forces and Motion
    - The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion. (MS-PS2-2)
    - All positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame and arbitrarily chosen units of size. In order to share information with other people, these choices must also be shared. (MSPS2-2)

- ETS1.A: Defining and Delimiting an Engineering Problem
    - The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that is likely to limit possible solutions. (MS-ETS1-1) (secondary to MS-PS3-3)
- ETS1.B: Developing Possible Solutions
    - There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. (MS-ETS1-2), (MS-ETS1-3) (secondary to MS-PS3-3)(secondary to MS-LS2-5)
    - Sometimes parts of different solutions can be combined to create a solution that is better than all of its predecessors. (MS-ETS1-3)

LESSON TIME FRAME

Two 45 minute class periods

BACKGROUND INFORMATION

Many technological advances have occurred in golf over time, including significant changes to the golf ball! Early golf was played with a stitched leather ball stuffed with boiled goose feathers. This egg-shaped ball cost three times as much as a club! In 1848, the gutta-percha ball was introduced. The gutta-percha was made from the sap of the gutta tree (a tropical tree native to Asia) and was considerably more durable and affordable than its predecessor. Additionally, golfers realized that markings and patterns on the gutta-percha enhanced its aerodynamics. The next advancement occurred in the early 1900s with the development of the Haskell rubber-cored balled which featured a gutty cover and a wound rubber core. It traveled up to 20 yards further than the gutta-percha ball and delivered greater durability. The rest of the 20th century was spent refining the Haskell ball. In 1905, William Taylor introduced the first dimpled ball. The dimples improved flight because the dimple pattern maximized lift and minimized drag. By 1930, the current golf ball with dimples was accepted as the standard design. In 1972, the first two-piece ball, the Executive, was introduced. Most modern golf balls consist of rubber thread wound around a rubber core and coated with dimpled enamel. Dimples are typically arranged in rows.

When a golf ball is hit, the impact determines its velocity, launch angle, and spin rate, which influence its trajectory and behavior when it hits the ground. A ball moving through the air experiences two major aerodynamic forces: lift and drag. Drag slows the forward motion, and lift acts in a direction perpendicular to it. Every modern golf ball has dimples designed to increase and shape the lift and drag forces by modifying the behavior of the boundary layer (the layer of fluid in the immediate vicinity of the surface). Drag and lift forces also exist on smooth balls, but dimpled balls fly farther because the dimples maximize lift and minimized drag, similar to the aerodynamics of an airplane wing. Golf balls with small, shallow dimples tend to have a longer, lower flight path. Those with deeper dimples have a higher flight path. Dimples do not all have to be the same size on a golf ball, they can be arranged in and designed in a way that the resistance to spinning is lower or higher along particular axes of rotation. Golfers can choose their balls based on what they need for a particular shot or in particular weather.

MATERIALS

Teacher Materials/Prep

- Flip chart paper or display the computer screen with a document to add notes to.
- Print copies
  - All in the Ball Trivia Challenge Student Capture Sheet
  - A Closer Look Student Capture Sheet
  - Good Sports Student Capture Sheet
  - Home Connections Resource to send home with students
- Print copies and cut out
  - Six Word Story Summary Student Capture Sheet

Materials per Student Group

- Several different types of golf balls (You can ask students to bring balls from home or visit a golf course/facility to donate balls.)
- All in the Ball Challenge Student Capture Sheet
- Closer Look at Golf Balls Student Capture Sheet
- Good Sports Student Capture Sheet
- Six Word Story Student Capture Sheet
- Scales
- Thread or string
- Rulers and meter sticks
- Flip chart paper or display a projection of a digital document
- Different pieces of sports equipment (optional) or different pictures of sports equipment
- Home Connections Resource
- Access to the Internet

CLASSROOM ACTIVITY

Day 1

Engage

1. As students enter the room, hold up a golf ball and ask them to name and describe what they see. Then ask students if they have any idea how the golf ball design and use is based on science. List all answers on the flip chart paper or digitally displayed document.
2. Distribute the “All in the Ball Challenge” student capture sheet. Divide students into small groups and direct each group to circle the correct answer for each question. Encourage them to make educated guesses if they are unsure of the answer.
3. Once all groups have finished, read each question out loud (or use a digital game tool to allow teams to compete with each other) and share the correct answer.
4. Read the correct answers after each question (see answer sheet) and have students keep track of their scores. Name one group the “All in the Ball” champions!
5. Challenge each group to look back at the questions and draw conclusions/add to their original answers on the flip chart paper about the golf ball design and its uses relate to science.

Explore

6. Review with students what they know about golf balls, including the fact that all golf balls are round and have dimples. What students may not know is that the size, shape, dimple arrangement, depth and pieces of golf balls vary and can determine the flight of the ball, the distance it travels, and how it behaves once it lands. Experienced golfers choose their balls based on their desired shot.
7. Distribute three to five different golf balls to each student group to examine. Also distribute the “Closer Look at Golf Balls” student capture sheet, scale, meter stick, tape measure, string, and scissors.
8. Have students complete each step on the activity sheet for each ball. Instruct them to fill in the answer on the chart. Then challenge them to answer the questions that follow.

Explain

9. Once all groups have completed the activity sheet, compare and discuss answers. At this point, you may want to share some of the “Background Information” with students. This includes the fact that balls with small, shallow dimples tend to have a longer, lower flight path and those with deeper dimples have a higher flight path. Golfers can choose their balls based on what they need for a particular shot or in particular weather. When a golf ball is hit, the impact determines its velocity, launch angle, and spin rate, all of which influence its trajectory and behavior when it hits the ground. A ball moving

through the air experiences two major aerodynamic forces: lift and drag. Drag slows the forward motion, and lift acts in a direction perpendicular to it. Every modern golf ball has dimples designed to increase and shape the lift and drag forces by modifying the behavior of the boundary layer (the layer of fluid in the immediate vicinity of the surface). Drag and lift forces also exist on smooth balls, but dimpled balls fly farther because the dimples maximize lift and minimize drag, similar to the aerodynamics of an airplane wing. Different construction can give balls different bounce-back ability. Balls with a harder core have a "higher" spring and are affected less at impact by the golf club.

10. Ask each group to summarize how they believe that the design of a golf ball impacts the game.

Day 2

Elaborate

11. Share with students that engineers continually work to improve products made by every industry, including sports. In this last part of the lesson, student groups will select a piece of sports equipment, learn how engineering has impacted its design and develop a sketch or prototype that improves it. Before they begin, ask students for some examples of how engineering and design has impacted sports.
12. Create three columns on the flip chart paper (or collaborative document): label the first column "sports," the second "safety," and the third "performance." In the first column, ask students to name 5-8 different sports. Then, for each sport, challenge them to brainstorm technology that is engineered to keep athletes safe, and technology that is engineered to help athletes perform their best. For example, if they name baseball, a batting helmet that prevents concussions could keep a player safe while a bat made from titanium could create further distance for a hit. Continue this activity until students have a good idea of several ways that design and engineering can improve and impact sports.
13. Then divide students into groups, distribute the "Good Sports" student capture sheet and review the directions with students. The activity sheet asks students to select a piece of sports equipment (ball, net, stick or club, shoe, apparel, helmet, etc.) and to conduct research to learn how the equipment has physically evolved over the last several years as a result of engineering. For example, has the shape, construction, size, or materials used to make the equipment changed? And how has the change impacted performance? Encourage students to use the piece of sports equipment or the picture of the sports equipment to help their analysis. Finally, each group is asked to use scientific principles to recommend one further change they would make to either enhance safety or performance.
14. Ask each group to present their ideas and sketches to the class and justify how their proposed change will impact safety or performance.

Evaluate

15. Finally, direct students to write a short paragraph describing how design and engineering can be used to help athletes perform their best or stay safe in a sport. Challenge them to include examples related to golf or other sports of their choice.

REFLECTION

Young scientists will reflect on their learning by completing the Six Word Story summary. Print off the Six Word Story Summary Student Capture Sheet, cut them out, and distribute one to each student. Alternatively, students may create this reflection activity in their science journal:

SIX WORD STORY SUMMARY

Exit Ticket:

Summarize your learning in **six** words.

______ ______ ______ ______ ______ ______

ALL IN THE BALL TRIVA CHALLENGE

Is your knowledge about golf balls "up to par?" Read the questions below and work with your group members to circle the correct answers.

1. Early golf balls were basically leather pouches filled with what? a. feathers b. pebbles c. cork	2. What shape were the first golf balls? a. round b. egg-shaped c. flat
3. What new feature was added to golf balls in 1905? a. different colors b. plastic coating c. dimples	4. Today, most pros use balls made out of how many pieces? a. one or two b. two or three c. three or four
5. A golf ball can be as big as you want, but it can't be smaller than what diameter? a. 1.68 inches b. 2.68 inches c. 3.68 inches	6. A golf ball cannot be heavier than how many ounces? a. 0.62 b. 1.62 c. 2.62
7. About how many dimples are on the average golf ball? a. 100-150 b. 200-350 c. 300-450	8. True or False: A golf ball must be round a. True b. false
9. No legal ball can exceed an initial velocity of what? a. 50 feet per second b. 150 feet per second c. 250 feet per second	10. Dimples on a golf ball increase what? a. Lift b. Drag c. Both lift and drag

ALL IN THE BALL TRIVA ANSWER KEY

1. A. feathers
2. B. egg-shaped
3. C. dimples
4. C. three or four
5. A. 1.68 inches
6. B. 1.62
7. C. 300-500
8. A. true
9. C. 250 feet per second
10. C. both lift and drag

A CLOSER LOOK

All golf balls are round and have dimples, but their size, shape, depth, and dimple arrangement may vary depending on a golfer's desired distance, flight and behavior after landing.

Number each of the golf balls and record the information about them below. To calculate the circumference, cut a piece of string and wrap it around each ball. Cut the string where the ends meet and measure it in centimeters. To complete the bounce test, drop each ball from about five feet and measure its bounce against a meter stick. Measure this a few times so you can obtain an average.

Ball Number	Weight (grams)	Diameter (cm)	Circumference (cm)	Observations about Dimples	Bounce Test (cm)

1. How do the measurements for the golf balls compare? How, if at all, do you think these measurements impact flight, distance, or behavior once the ball hits the ground?
2. How do the dimples compare in terms of number, depth and pattern? How, if at all, do you think these differences impact flight, distance, or behavior once the ball hits the ground?
3. Did the golf balls bounce the same height? What might account for any bounce differences? How could a ball's bounce impact flight, distance, or behavior once the ball hits the ground?
4. What conclusions can you draw about the way a golf ball's design can impact a golfer's shot?

GOOD SPORTS

Engineering and design are continually applied to improve products made by every industry, including sports. Some technological advances help to keep athletes safe while others enhance performance. The advances to the golf ball you learned about throughout this lesson were designed to impact performance, specifically flight, lift, and behavior once the ball hits the ground. In this activity, you will have the opportunity to learn about advances in a piece of sporting equipment or apparel and then come up with a design enhancement of your own.

1. With your group members, identify one piece of sporting equipment or apparel that you would like to improve.
2. Conduct research to learn when, where, and by whom your equipment was invented. Then research and list major advancements from its invention to now. You can do this in a timeline, pictorial, or paragraph. Include any relevant information about how major advancements have helped to enhance safety or performance.
3. Finally, come up with one way that you would like to further improve either safety or performance related to your equipment. List your goal below. Then create a sketch of the new design that includes a scientific justification for your change.

SIX WORD STORY SUMMARY

Exit Ticket: Summarize your learning in **six** words.

__________ __________ __________ __________ __________ __________

Exit Ticket: Summarize your learning in **six** words.

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Exit Ticket: Summarize your learning in **six** words.

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Exit Ticket: Summarize your learning in **six** words.

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HOME CONNECTIONS

Parent Background Information:

Engineers play an important role in sports. The three goals of engineering sports equipment are typically known as lighter, faster, and stronger. Lighter equipment helps athletes move with as little extra weight as possible. Think about the lightness of a snowboard, BMX bike, or even a bathing suit. Faster equipment helps the athlete overcome as much friction as possible. Friction is the enemy of many sports! Think about skiers who put wax on the bottom of their skies to create less friction between the snow and the skies or the golfer who uses a certain glove to help with a smooth grip. Stronger equipment allows athletes to feel confident that their equipment won't break even under extreme force. Baseball bats, for example have to be strong enough to absorb the impact of hitting the ball with great force. Football helmets and pads need to have the right materials so that players are protected from forceful hits. Different types of engineers work on different aspects of sports equipment: Materials engineers help to decide the best materials for equipment. Design engineers help to make protective gear comfortable and easy to use. And biomedical engineers analyze the body's motion in sports to find ways to reduce injury and optimize performance.

With your young scientist, look through your garage, closets, or sports bags to find several pieces of sporting equipment or clothing. Pass the objects around and have each family member share one way that they think engineering and design have helped to make the equipment or apparel lighter, faster, stronger, or safer.