The Science, Technology, Engineering and Math of Golf
WHAT’S STEM?

STEM stands for Science, Technology, Engineering and Math.

The amazing thing about STEM is that it’s part of life all around us—the weather, cars and even the sports you watch and play—including golf!

And it turns out science and math have a lot to do with golf.

What is the STEM ZONE?

A few years ago, Chevron partnered with the United States Golf Association (USGA) to create an engaging experience to help show the cool science behind the game of golf. The STEM ZONE is a tent that has tons of fun experiments and can be found at the U.S. Open Championships.

The STEM ZONE was such a hit, that Chevron and the USGA are now bringing the math and science of golf to young people nationwide through digital and interactive experiences.

STEM Resources

STEM NEWS, created by the internationally syndicated Kid Scoop, gets the scoop on the many ways sports and science collide with hands-on activities and learning experiences—in fact, you are reading it right now! STEM NEWS is distributed through newspapers around the country, at USGA golf championships and is available online. A teacher guide is available.

STEM TOOLKITS

These printable toolkits provide STEM lessons and activities for golf pros, teachers and youth organizations to teach young people golf and STEM at the same time. Coming in July.

INTERACTIVE MODULES

These interactive modules explore STEM concepts and allow kids to learn STEM principles in a fun and interactive way. Coming in July.

STEM VIDEOS

NBC Learn has partnered with the USGA and Chevron to create 20 informative videos that explore STEM subjects at work in the game golf! Lesson plans go with each video.

Find these resources and more at www.usga.org/chevron.

Careers That Are Part of the Game!

Science and math have a role in playing the game of golf. STEM concepts are also key to keeping the game challenging and fair. The USGA has a laboratory and a staff of scientists at their USGA Test Center.

The USGA Test Center tests golf balls, clubs, and other equipment to determine whether or not they conform to the Rules of Golf.

Clubs and balls are tested to determine they don’t have properties or features that would make their use unfair, or eliminate the challenge and skill required to play the game.

STEM NEWS puts the spotlight on the USGA Test Center and the scientists and engineers who get to play with golf balls, clubs, robots and other cool stuff everyday!

Just turn the pages and discover how you can conduct the same kinds of experiments done at the USGA Test Center while gaining first-hand knowledge of careers more like a game than work.

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The faster a golfer can make a golf ball go, the farther it will travel. How does a golfer get a ball to go faster? It’s science! The swing of a golf club is like a pendulum.

Scientists’ Notebook

Question: Does the length of swing change the speed of the ball?

Hypothesis: (Your guess here)

Experiment:

1. Pour the rice into the sock and knot the open end.
2. Tie one end of the string around the knot in the sock. Securely tape the other end to the top edge of table so that the sock hangs just above the floor.
3. Set the ball on the floor so that its side touches the sock. Pull the sock about 3 inches (5 cm) away from the ball. Release the sock and let it hit the ball.
4. Allow the ball to roll to a stop. Use the tape measure to measure how far it traveled.
5. Repeat steps 3-4, pulling the sock back about 10 inches (25 cm).

Conclusion: Was your hypothesis correct? □ YES □ NO

What did you learn from this experiment?_________________________

Some people think golf is a slow game. But it clocks some of the highest speeds in the world of sports! Hitting a ball hundreds of yards into a tiny hole with the least strokes possible requires some serious speed.

STEM Connection: The swing of the golf club is like the hanging sock pendulum. The weight and mass of the sock stayed the same – but the distance the sock traveled changed. Golfers use their longest clubs when hitting off the tee. A shorter club can’t get the same speed.
Engineering is man’s application of scientific and mathematical knowledge to build nearly everything we see around us. Computers, buildings, bridges, ships, planes and – YES – even the equipment used in the game of golf.

EASIEST QUIZ EVER

CHECK “YES” FOR EACH THING BELOW THAT REQUIRES ENGINEERING:

- Bicycle
- Ship
- Airplane
- Drum
- Guitar

WHAT IS A VARIABLE?

In experiments, a variable is something that can be changed, or can affect the outcome of an experiment in different ways.

ROBOT GOLFER

The USGA Test Center uses a Robot Golfer to test more than 30,000 golf balls per year.

“It is important to use the robot,” says Dr. Steven Quintavalla, senior research engineer at the USGA Test Center. “With the robot we can keep the speed of the swing the same each time. That way the only thing that changes is the ball.”

Q: Why do you think it is important for only the ball to change when testing balls with the Robot Golfer?

FAST-PACED RESEARCH

At the USGA Test Center, Dr. Quintavalla studies golf balls and other golf equipment. He also helps the USGA write rules that make sure the game is played fairly.

Dr. Quintavalla likes the fact that when he goes to work each day, there are always new and different challenges. Because advances in technology lead to new equipment, he and the USGA team are there to review and test them.

“Even though technology can improve and change, it’s important to make sure the game of golf is first and foremost a game of skill,” says Quintavalla. “When new golf equipment comes out, we check to make sure that it conforms to the Rules of Golf.”

And, Dr. Quintavalla likes things that go fast – like golf balls and the race cars he works on in his spare time!
1618: A new type of ball was created by stuffing a wet leather pouch with goose feathers. As the leather and feathers dried, the leather shrunk and the feathers expanded to create a hard, compact ball.

1848: The Rev. Dr. Robert Adams discovered he could make a hard ball from the sap of the Gutta-percha tree. The rubber-like ball became known as a “gutty.” Players discovered that older, nicked and dented gutties flew farther than smoother, new ones. The “Hand Hammered Gutta” ball was invented. A consistent pattern of dents was hammered over the entire ball surface.

1898: Coburn Haskell worked with the BF Goodrich Company to create a ball with a solid rubber core, wrapped with a high-tension rubber thread (like a long rubber band) and coated in a Gutta-percha cover.

TODAY: Modern golf balls have a three-layer design: a solid, bouncy rubber core, a plastic-like layer that is strong and stiff and a thin, dimpled outer layer.

In the quest for speed and distance, the materials used to make golf balls have changed over the centuries. The first golf balls were hard wooden balls. These were used until the early 17th century.

A golf ball can weigh no more than 1.62 oz (45.93 grams), and have a diameter no less than 1.680 in (42.67 mm).

Golf balls can’t go any farther than 317 yards (289.9m) when hit at 120 mph by the USGA’s test robot, and they have to go the same distance no matter how you line them up.

**FUEL FOR THOUGHT**

**WHICH IS THE BETTER GOLF BALL?**

a. Shiny, smooth ball

b. Used, ding-ed up ball

Through the years, players discovered that golf balls with dings and dents flew farther. Those bumps and dents reduce wind resistance causing balls to travel farther.

**STEM in the News**

Look through the sports section for photos of equipment - helmets, cleats, clubs, etc. Cut out one example and write a brief summary about the object’s purpose and importance to the game. Complete the sentence:

Engineering may have been used to ____________________________.

Imagine if you could buy a rocket-propelled golf ball. This would allow a player to get a better score even with poor golf skills. Technology would eliminate the need for a player to develop skill, which would take the fun out of golf.

**FUEL FOR THOUGHT**

**WHICH IS THE BETTER GOLF BALL?**

1. A smooth golf ball travels further than one with nicks and dents.  
   - \[\text{TRUE} \quad \text{FALSE}\]

2. A “gutty” is a nickname for a golf ball made of tree sap. 
   - \[\text{TRUE} \quad \text{FALSE}\]

3. Golf balls used in pro tournaments today have multiple layers. 
   - \[\text{TRUE} \quad \text{FALSE}\]

4. Early golfers hand-carved their own golf balls. 
   - \[\text{TRUE} \quad \text{FALSE}\]

5. Feather-stuffed golf balls travel farther than rubber ones. 
   - \[\text{TRUE} \quad \text{FALSE}\]

**STEM Connection:** Imagine if you could buy a rocket-propelled golf ball. This would allow a player to get a better score even with poor golf skills. Technology would eliminate the need for a player to develop skill, which would take the fun out of golf.
The earliest golf clubs were carved from a single block of wood. They were handmade – often made by the golfers themselves – and there was no standard design. Golfers called their clubs “woods.” When clubs were made out of metal, they were still called “woods.” Golfers discovered that when they hit a golf ball with a hollow steel club, they had more control over the ball. Today clubs are made with titanium because it is very strong and much lighter than steel. This makes it possible for the club head to be larger, which distributes the weight even farther away from the center, making it possible for a golfer to hit the ball more accurately.

In my day, when we said a club was made of wood, we meant it!

People have been hitting balls with sticks for a long time. In the 1400s, the Scots invented a game played by hitting a little ball with a stick over a course with 18 holes. This was the beginning of the game of golf.

“Dr. Matt Pringle’s knowledge of science got him the job of studying how golf clubs and golf balls work. He uses what he learns in these studies to help write the rules for equipment used in the game of golf.

“I get paid to study sports for a living! And, I get to travel all over the world,” Dr. Pringle says. “I’m pretty lucky!”

Dr. Pringle invented “TruFirm,” a tool that measures the firmness of golf turf and bunker sands. Why do you think it is important to know the firmness of golf course grounds?

A hollow club head distributes the weight of the club along its outside edges (perimeter).

When the club hits the golf ball, the club is less likely to turn. If a club turns when it hits the ball, it can change the direction the ball will fly, and the ball will not go as far.

Math in the STEM ZONE
Sports Math: Identify ten different ways math is used in the sports section of the newspaper.
GOLF CLUB RULES

In professional and amateur golf, the head of the club can be no more than 2.8 in (7.1 cm) high and 5 in (12.7 cm) wide. The volume can be no larger than 28.07 cubic inches (460 cubic centimeters).

Measuring the height and width of a club is straightforward. But how do you measure the volume? To find out read the Scientist’s Notebook.

ARCHIMEDES DISPLACEMENT EXPERIMENT

The Ancient Greek mathematician, Archimedes, discovered that the volume of an object can be determined by measuring the change in water level (displacement) when an object is placed in it.

At the USGA Test Center, the club head is attached to a shaft which is mounted to hold the club head in the exact location needed for an accurate measurement. The club is then submerged and the level of displacement is measured.

FUEL FOR THOUGHT

AMAZING MEASURING! IN 3-D!

Two Dimensions

Three Dimensions

When we use a ruler to measure the length of a line, that is measuring in one dimension. Measuring the area of a flat surface is measuring in two dimensions. Measuring in 3-D is called measuring something’s volume.

Scientist’s Notebook

Record the measurement before an object is dropped into each graduated cylinder. Then record the level after it is in the water. The difference between these two levels is the VOLUME.

STEM Connection: If a golf club had a targeting laser that lined up a golfer’s shot, a player could get a better score even with poor aiming skills. As technology improves golf equipment, it is important to have rules which keep the game a challenge of skill.

STEM workers typically use metric measurement because it is internationally accepted and understood.

Interestingly, the USGA uses the British Imperial System of measurement – which includes inches, feet and yards – in their measurements, because of golf’s history and tradition. After all, the game did get its start in the British Isles.
Scientists and engineers use the rules of aerodynamics to make things go fast and far—like race cars, jet planes, and golf balls! You may see a funny, bumpy ball sitting on a tee. But when you take it into the STEM ZONE, a golf ball looks *aerodynamic*!

The word *aerodynamic* comes from two Greek words:

**AEREOES**
**DYNAMIS**

**OF THE AIR**
**POWER, STRENGTH, FORCE**

Scientists and engineers use the rules of aerodynamics to make things go fast and far—like race cars, jet planes, and golf balls!

**WHAT A DRAG!**

This golf cart has enough speed to move it through the air, but not enough to counter the drag of the water.

**GOLF ON THE MOON**

Astronaut Alan Shepard found out when he walked on the moon on Feb. 6, 1971. Even wearing a bulky space suit, he hit a ball that traveled 400 yards (366 meters). On earth the average golfer can hit a ball about 200 yards (183 meters).

“**What other people may find in poetry or art museums I find in the flight of a good drive.**”

— Arnold Palmer

The impact, or hit, of a golf club on a ball gives it speed to move. **Drag** is an opposite force that slows a moving object.

Most round objects (like a golf ball) have less drag than flat objects (like a cube).

Wave your hand through the air. You can feel the drag of the air. You can feel it against your face when riding your bike.

Air slows down moving objects. So what would happen if you hit a golf ball on the moon where the air is much thinner than on earth?
WEIGHT AND LIFT

The weight of an object makes it harder to lift. Have you ever wondered how a full passenger jet, which weighs about 300,000 pounds, can fly? Aerodynamics!

Golf balls do not create as much lift as a passenger jet, but they do create enough to greatly increase hang time, and therefore, distance.

As a golf ball travels through the air, wind resistance creates drag, which slows the ball down. The dimples on a golf ball reduce the drag of the air making it possible for the ball to go faster and farther.

At the USGA Test Center, scientists created a 70-foot-long tunnel to test golf balls. A machine shoots out golf balls at 190 mph. Infra-red sensors along the tunnel record the flight of the ball as it flies through the tunnel. The sensors send this data to a computer for analysis.

The indoor test tunnel is used by golf ball companies around the world as they develop new golf balls for the sport.

STEM in the Newspaper

STEM workers are problem solvers. Locate a problem in the sports section of the newspaper that an athlete or team faced. Write about and illustrate an invention to solve it!

Scientists’ Notebook

**Question:** What will happen to a strip of paper if you blow over the top of it?

**Hypothesis:** (Your guess here)

**PAPER PUZZLER**

**Stuff You’ll Need:**
- Strip of paper 2 inches (5cm) wide and 6 inches (15cm) long
- You (and your lungs!)

**Experiment:**
1. Fold one end of the strip of paper about 1 inch (or 2 cm) from the end and hold it beneath your bottom lip.
2. Blow a long, steady stream of air down and over the top of the strip of paper.
3. Repeat a few times.

**Conclusion:** Was your hypothesis correct? □ YES □ NO
What did you learn from this experiment?

**Faster-moving _____ has a ______ pressure, so the paper is ______ by the higher air pressure ________. This is called Bernoulli’s Principle.**

STEM Connection: Bernoulli’s Principle explains how objects generate aerodynamic lift. Lift is partly responsible for getting golf balls to travel as far as they do.
When scientists at the USGA Test Center test golf clubs and balls, it is important to make sure that tests don’t contain mistakes. That is John Spitzer’s job – to be sure the tests are done correctly and the data collected is accurate.

“We have to be positive that none of the balls or clubs people use when they play golf give them an unfair advantage,” says Spitzer.

“I love my job because I get to see all of the new golf balls and clubs before anyone else!”

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**STOP RIGHT THERE!**

Friction slows or stops moving things. A rolling ball eventually stops because friction between the ball and the ground brings it to a stop.

When a golf ball is struck accurately by a slanted, or lofted club, the ball will tend to roll up the club-face before it launches. This causes the ball to have **backspin**.

But if the ball is hit with the bottom of the club-face, the ball will get **topspin** causing the ball to go downward toward the ground.
A special machine at the USGA Test Center shoots a golf ball out of a gun through a tunnel toward an angled target. A camera uses video and slow motion photography to observe and measure the spin. Golf ball manufacturers want to know how a ball's construction affects its spins.

Q: Does hitting a more steeply angled surface cause a ball to spin more?

The data below illustrates actual USGA Test Center results for a test that measures a golf ball's spin speed when it hits different angled surfaces at 55 miles per hour.

<table>
<thead>
<tr>
<th>ANGLE (degree)</th>
<th>Spin (RPM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>1100</td>
</tr>
<tr>
<td>20</td>
<td>2300</td>
</tr>
<tr>
<td>30</td>
<td>4000</td>
</tr>
<tr>
<td>40</td>
<td>6000</td>
</tr>
<tr>
<td>50</td>
<td>7200</td>
</tr>
<tr>
<td>60</td>
<td>7500</td>
</tr>
</tbody>
</table>

RPM is Revolutions Per Minute. This is the term used to describe spin speed.

For a long drive, a golfer needs to understand __________ to get just the right amount of backspin. Spin creates ________, so the ball stays in the air ___________. That's thanks to ____________!

With more hang time, the ball travels ___________. Too little spin, and the ________ doesn't lift enough to travel down the fairway.

However, too much spin increases the wind ____________, which makes the ball slow in the air. When the ball _________ down too much, it falls down. Getting just the __________ amount of spin is important to make sure the ball will reach the maximum ________________.

For short hits on to the green, more spin can __________ the ball. If the ball doesn't spin __________, it can bounce and roll too far. With a lot of spin, the ball can actually roll ____________.

Controlling spin lets players control where the ball will ____________, so that they can get the ball close to or in the _______________.

STEM Connection: To do well in a game of golf, a golfer wants to control the speed and direction of the golf ball. The spin of a golf ball affects its speed and direction. Different angled clubs will produce different results.

Graph It! It's your turn to be an engineer and record the results on a bar chart. Follow these steps:

1. From the “0” point, create six evenly spaced intervals along the X axis. Label the intervals from 1000 to 8000. Name the Y axis “SPIN.”

2. From the “0” point, create eight evenly spaced intervals along the Y axis. Label the intervals from 10 to 60. Name the X axis “ANGLE.”

3. Begin with the 10 degree angle and draw a bar to approximately the 1100 point.

4. Continue to fill in the angle/spin data.

Time Capsule
Gather STEM related articles from today’s newspaper to place in a time capsule. What do the articles tell us about our current technology?
Mary Jane Rogers is a Research Assistant at the USGA Test Center. Her job is to collect and analyze data to help determine if equipment meets all of the Rules of Golf.

“I like being involved with the different studies and experiments that go on at the USGA,” says Rogers. “I love studying about how the body functions and about body movement. I even got to stay awake to watch my own knee surgery!”

Her job requires a lot of attention to detail. She must be very observant.

When a ball is held above the ground, it has a lot of potential energy and no kinetic energy. As it falls, it starts losing its potential energy and gets kinetic energy.

When the ball hits the ground, it has lots of kinetic energy. The friction against the ground slows the ball down, but it also slightly heats the ball. This is thermal energy.

The ball bounces back up but to a lower height than where it started. The original potential energy was transformed into thermal energy.

If you answered “b” you are right.

When a ball is dropped to the ground, it comes back up almost to the point it was dropped from, but not quite.

A scientist will tell you the explanation is about energy. There are different kinds of energy:

**KINETIC ENERGY**
Anything that is moving has kinetic energy, and the faster it is moving, the more kinetic energy it has.

**POTENTIAL ENERGY**
An object high above the ground has potential energy because of the work it took to get it there and the work it will do when it falls down.

When a ball is dropped, its potential energy is changed into kinetic energy. An important rule is that energy can’t be created or destroyed. It can only change into different forms of energy. This is called Conservation of Energy.

Q: How high will a golf ball bounce when dropped from shoulder height?

- a. back to shoulder height
- b. less than shoulder height

If you answered “b” you are right. When a ball is dropped to the ground, it comes back up almost to the point it was dropped from, but not quite.

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How observant are you? Look at the golfer on this page. List 10 details about the picture. Then have a friend try it. Compare.
At the USGA Test Center, a special machine with a big flywheel is used to test a golf ball’s bounce energy when the ball is hit by a club. A ball is hit by the special flywheel through a machine that measures its speed. The rule in golf is that a ball cannot travel faster than the speed of 173.9 MPH when bounced off this flywheel. (That’s 255 feet per second!)

The “bounce” energy of a golf ball plays a big role in the distance it will travel once it is hit with a golf club. To keep competitions and games fair, players need to use golf balls that don’t go faster than the allowed maximum speed.

**rules of golf**

**STEM News**

**Measuring a Golf Ball’s Bounce**

<table>
<thead>
<tr>
<th>FLYWHEEL</th>
<th>BALL IS HIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>BALL BOUNCES OFF HARD SURFACE IN THE MACHINE</td>
<td></td>
</tr>
<tr>
<td>GOLF BALLS ARE TESTED AT THE USGA TEST CENTER TO MAKE SURE THEY COMPLY WITH THE RULES OF GOLF</td>
<td></td>
</tr>
</tbody>
</table>

**Font Math**

Measure the height of a headline in today’s newspaper or an online article. Next measure the height of the text in the article. Calculate the ratio.

**Scientist’s Notebook**

Imagine dropping a golf ball from the top of these famous structures. If the ball bounces 80% of the way back up toward the top, how many feet/meters high would the ball travel for each? (We did the first one for you. Are we cool or what?)

<table>
<thead>
<tr>
<th>Structure</th>
<th>Height (in feet)</th>
<th>Height (in meters)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Statue of Liberty</td>
<td>305 feet</td>
<td>93 meters</td>
</tr>
<tr>
<td>Washington Monument</td>
<td>565 feet</td>
<td>169 meters</td>
</tr>
<tr>
<td>Space Needle</td>
<td>604 feet</td>
<td>184 meters</td>
</tr>
<tr>
<td>Transamerica Pyramid</td>
<td>1,066 feet</td>
<td>325 meters</td>
</tr>
<tr>
<td>Empire State Building</td>
<td>1,454 feet</td>
<td>445 meters</td>
</tr>
</tbody>
</table>

**STEM Connection:** The “bounce” energy of a golf ball plays a big role in the distance it will travel once it is hit with a golf club. To keep competitions and games fair, players need to use golf balls that don’t go faster than the allowed maximum speed.
Bob Jones is considered the greatest amateur in the history of golf. He was the first and only golfer to win the Grand Slam – four back-to-back prestigious tournaments that included the British Amateur, the British Open, the U.S. Open and the U.S. Amateur in the same year.

Jones knew that being a champion is about more than just the right equipment. Golfers need skill and knowledge.

Once a golfer has the ball on the green, hitting for speed and distance is no longer the objective. Now the goal is to hit the ball in such a way that it will go into the hole. And that takes a knowledge of science.

When I hit the ball toward the hole, the slope of the green will cause it to curve, or break, as it rolls forward and downhill at the same time. To land the ball into the hole, I need to hit the ball slightly uphill from the hole.

Although golf course greens may appear flat, most have undulations and dips that prevent a ball from traveling in a straight line. Golfers must take these surface slopes into consideration. Gravity will always pull the ball downward.

The putter must make the ball curve, or break, toward the hole.

“Golf is a game that is played on a five-inch course—the distance between your ears.”

– Bob Jones

Q: WHAT DO YOU DO AT THE USGA TEST CENTER?

A: I develop and monitor tests that measure how well new golf balls and golf clubs work. I work with professional golfers to see how new models of golf balls and clubs work for them.

Q: WHAT DO YOU LIKE BEST ABOUT YOUR JOB?

A: I like using a variety of skills and the chance to be creative. I get to use robots, computers and radar in our test labs and outside on golf courses. And, I get to travel. It’s a great job!

Q: BESIDES SCIENCE, WHAT ELSE DO YOU ENJOY?

A: As a scientist, some might find it surprising that I enjoy art and carpentry. Engineers and scientists are often creative and like to work spatially.
**Fuel for Thought**

**Gravity: A Weighty Problem**

Weight is actually the result of gravity pulling on the mass of an object. (Everything—including you—is made of stuff, mass is the stuff.)

If you travel to another planet, your mass would stay the same, but your weight would change depending upon the planet’s gravitational pull on you.

For example, if you weigh 100 pounds and visit a planet with twice the gravitational pull, you would weigh 200 pounds on that planet.

**Break for Lunch?**

There are no machines at the USGA Test Center that measure “Breaking on the Green.” It takes practice and skill to determine the slope of the green and to decide how hard to hit a ball.

At their lunch hour, Test Center scientists head out to the USGA greens to experiment putting golf balls with different amounts of force and direction.

**Scientist’s Notebook**

Complete the crossword puzzle below to review the STEM Zone™ terms and concepts you’ve read about in this special supplement.

<table>
<thead>
<tr>
<th>Across</th>
</tr>
</thead>
<tbody>
<tr>
<td>4. a weight hung from a point so it can swing freely (Page 3)</td>
</tr>
<tr>
<td>6. oversee or regulate (Page 4)</td>
</tr>
<tr>
<td>8. a person who designs, constructs and uses engines (Page 4)</td>
</tr>
<tr>
<td>9. capable of being, energy stored (Page 12)</td>
</tr>
<tr>
<td>10. any force that slows motion or drags (Page 8)</td>
</tr>
<tr>
<td>12. a set of tools, devices or materials (Page 4)</td>
</tr>
<tr>
<td>13. a theory or idea to guide an investigation (Page 3)</td>
</tr>
<tr>
<td>14. relating to generating heat caused by raising temperature (Page 12)</td>
</tr>
<tr>
<td>15. related to motion or movement (Page 12)</td>
</tr>
<tr>
<td>16. the force by which objects fall toward the center of the earth (Page 15)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Down</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. a slanted club, when hitting a ball accurately, will generate this (Page 10)</td>
</tr>
<tr>
<td>2. a slanted club will lift the ball upward (Page 10)</td>
</tr>
<tr>
<td>3. to introduce something new (Page 12)</td>
</tr>
<tr>
<td>5. the volume of liquid pushed out of the way by an object that takes its place (Page 7)</td>
</tr>
<tr>
<td>7. slant or curve (Page 11)</td>
</tr>
<tr>
<td>10. a force that raises (Page 13)</td>
</tr>
<tr>
<td>11. measurement in length, width and/or thickness (Page 7)</td>
</tr>
<tr>
<td>12. the way air moves around objects (Page 8)</td>
</tr>
<tr>
<td>14. surface resistance when one object moves against another (Page 10)</td>
</tr>
<tr>
<td>15. the result of gravity pulling on an object (Page 15)</td>
</tr>
<tr>
<td>16. relating to, or having the character of space (Page 14)</td>
</tr>
<tr>
<td>17. the region of slow-moving fluid immediately behind an object, caused by the faster flow around it (Page 9)</td>
</tr>
<tr>
<td>18. the distance or border around an object (Page 6)</td>
</tr>
<tr>
<td>22. a test to provide evidence for or against a hypothesis (Page 9)</td>
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<td>23. the amount of space an object occupies (Page 7)</td>
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**STEM in Your Future?**

STEM in Your Future? Look through the newspaper want ads to identify careers in science, technology, engineering or math. Count different careers. Graph results.

**STEM Connection:** Advances in technology and expert engineering have improved the equipment used by golfers. The USGA Equipment Standards Department uses math and science to evaluate new equipment to ensure that skill, not technology, determines success in golf.
Join us for Junior Day at the U.S. Women’s Open

**JUNE 18—JUNIORS GET IN FREE**

**ACTIVITY SCHEDULE**

**REGISTRATION AT CHEVRON STEM ZONE**
Wednesday, June 18: 8 a.m. – 12 noon
Juniors will register at the Chevron STEM ZONE for U.S. Women’s Open Junior Day. Lunch vouchers, which will be redeemable at several concession areas around the golf course, will be provided at registration. Juniors can also pick up a scorecard to play a round at the Thistle Dhu Putting Course.

**CHEVRON STEM ZONE**
Wednesday, June 18: 8 a.m. – 5 p.m.
Visit the Chevron STEM ZONE for interactive, multimedia experiences which demonstrate the cool science behind the game of golf.

**THISTLE DHU PUTTING COURSE**
Wednesday, June 18: 10 a.m. – 2:45 p.m.
Play a round on Pinehurst’s Thistle Dhu, an 18-hole putting course that provides an entertaining playing experience. Juniors must pick up a scorecard in the Chevron STEM ZONE to play.

**U.S. WOMEN’S OPEN JUNIOR CLINIC**
Wednesday, June 18: 3-4 p.m.
The U.S. Women’s Open Junior Clinic will be hosted by the Golf Channel’s Mark Rolfing and attended by past U.S. Women’s Open champions and current players.

**U.S. WOMEN’S OPEN FAMILY NIGHT IN THE VILLAGE OF PINEHURST**
**Wednesday, June 18: 5-9:30 p.m.**
The evening will be held at the U.S. Open Experience in Tufts Park. Events will include special interactive programming, prizes, and a movie. Free ice cream will be available!

And on **Saturday, June 21: 11 a.m.**
**DENNIS WALTERS CLINIC**
The Dennis Walters Golf Show is a one-hour combination of “Golf Lessons and Life Lessons.” It is great golf, great fun, along with an inspiring message.

**REGISTER AT:**
girlsgolf.org/pages/events/junior-clinics

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**MORE STEM LEARNING RESOURCES:**

**SCIENCE OF GOLF VIDEOS**
NBC Learn offers 20 informative videos, with accompanying lessons plans, bringing the science of golf to life.

**INTERACTIVE MODULES**
Digital, interactive learning modules that engage students in STEM concepts such as weather, volume, and aerodynamics. Coming in July.

**STEM TOOLS**
STEM lessons, experiments, and activities for golf professionals, volunteers, teachers, and youth organizations. Coming in July.

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**Pinehurst Resort • 80 Carolina Vista Drive • Pinehurst, NC 28374**

*Junior Policy: Kids 17 and under are free on June 18, 2014 only.*