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.

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.

STEM Resources

STEM NEWS
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.

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.
NEWTON’S FIRST LAW OF MOTION

Any object at rest will stay at rest, until a force causes it to move. An object in motion will stay in motion, until a force causes it to stop.

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.

Scientist’s 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 (6 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.

SciThe 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.

This experiment uses a pendulum to show how the length of the swing affects the distance a ball travels.

THE STUFF YOU’LL NEED:
• 1 cup dry rice
• old sock
• 3’ piece of string
• small ball
• desk or table
• tape measure

FUEL FOR THOUGHT

WHICH IS FASTER?

Do the math to find out.

RUNNING CHEETAH
(30 x 2) + 10 = _______ MPH

PRO BASEBALL PITCH
(31 x 3) + 3 = _______ MPH

PRO HOCKEY SHOT
(33 x 3) + 1 = _______ MPH

PRO TENNIS SERVE
(54 x 2) + 47 = _______ MPH

PRO GOLFER DRIVE
(58 x 3) + 1 = _______ MPH

Speed in the STEM Zone™

Speed is about motion. An English scientist named Isaac Newton came up with ideas about motion that have been tested and proven again and again. His ideas are called Newton’s Laws of Motion.

NEWTON’S FIRST LAW OF MOTION

Any object at rest will stay at rest, until a force causes it to move. An object in motion will stay in motion, until a force causes it to stop.

STEM NEWS 3
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
- Horn

**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.

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**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.

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Use the information above to determine which of the following statements are TRUE or FALSE.

1. A smooth golf ball travels further than one with nicks and dents.
2. A “gutty” is a nickname for a golf ball made of tree sap.
3. Golf balls used in pro tournaments today have multiple layers.
4. Early golfers hand-carved their own golf balls.
5. Feather-stuffed golf balls travel farther than rubber ones.

TRUE FALSE TRUE FALSE TRUE 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.

The chances of making two holes-in-one in a round of golf are one in 67 million.

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?

“The important thing is not to stop questioning. Curiosity has its own reason for existing.”

– Albert Einstein

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.

**FUEL FOR THOUGHT**

**AMAZING MEASURING!**

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.
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:

AEROES 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

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?

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
**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.

Dimples on a golf ball reduce drag and increase lift. Here’s how:
The air boundary around a golf ball with no dimples is wider. This creates a thick wake behind the ball and more drag.

**Scientist’s Notebook**

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

**Hypothesis:** (Your guess here)

**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.**
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!”

“A gem cannot be polished without friction nor a man perfected without trials.”
– Lucius Annaeus Seneca
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>

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 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.
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.

Math and science are the engines of innovation. With these engines we can rule the world.”
– Dr. Michael Brown

OKAY, LET’S DROP IT!

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.

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.

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.

Making Equipment Fair

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.
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!)

**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.

**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.

**THE UPS AND DOWNS OF PUTTING**

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.

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**Scientist’s Notebook**

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

**Across**

4. a weight hung from a point so it can swing freely Page 3
6. oversee or regulate Page 4
8. a person who designs, constructs and uses engines Page 4
9. capable of being, energy stored Page 12
12. any force that slows motion or drags Page 8
19. a set of tools, devices or materials Page 4
20. a theory or idea to guide an investigation Page 3
21. relating to generating heat caused by raising temperature Page 12
22. related to motion or movement Page 12
23. the force by which objects fall toward the center of the earth Page 15
24. the result of gravity pulling on an object Page 15
25. relating to, or having the character of space Page 14

**Down**

1. a slanted club, when hitting a ball accurately, will generate this Page 10
2. a slanted club will lift the ball upward Page 10
3. to introduce something new Page 12
4. the volume of liquid pushed out of the way by an object that takes its place Page 7
5. slant or curve Page 11
6. a force that raises Page 13
7. measurement in length, width and/or thickness Page 7
8. the way air moves around objects Page 8
9. surface resistance when one object moves against another Page 10
10. the result of gravity pulling on an object Page 15
11. relating to or having the character of space Page 14
12. the region of slow-moving fluid immediately behind an object, caused by the faster flow around it Page 9
13. the distance or border around an object Page 6
14. a test to provide evidence for or against a hypothesis Page 9
15. the amount of space an object occupies Page 7
16. breaking on the green for putting Page 10
17. a test to provide evidence for or against a hypothesis Page 9
18. the result of gravity pulling on an object Page 15
19. related to motion or movement Page 12
20. a person who designs, constructs and uses engines Page 4
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**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.
OKLAHOMA STUDENTS:
Experience all the FUN of the Chevron STEM ZONE™ at the U.S. Senior Open!

KIDS GET IN FREE!*

Sometimes the study of math and science can seem disconnected from the “real” world. Yet, a closer look at something fun, like golf, from a scientific perspective reveals connections to life and careers that are instructive and engaging.

At the U.S. Senior Open Championship at Oak Tree National in Edmond, Oklahoma, kids will have the opportunity to experience the Chevron STEM ZONE™:
An interactive, hands-on experience that shows how the game of golf and STEM principles connect.

*Junior Policy: Kids 17 and under are free with a ticketed adult the entire week of the U.S. Senior Open

CHEVRON STEMZONE

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

INTERACTIVE MODULES
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STEM TOOLKITS
STEM lessons, experiments, and activities for golf professionals, volunteers, teachers, and youth organizations. Coming in July.

U.S. SENIOR OPEN
2014
OAK TREE NATIONAL
Edmond, Oklahoma
July 7 - 13, 2014

All resources can be found at www.usga.org/chevron

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