The Science of Golf

Test Lab Toolkit
The Course: Water

Grades 9-12

USGA

Science | Technology | Engineering | Mathematics

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Test Lab Toolkits bring math and science to life by showing how STEM studies play a big role in the game of golf. They are funded by the United States Golf Association (USGA).

USGA

Welcome to the Test Lab Toolkit!

Sometimes the study of science and math can seem a little disconnected from the "real" world, a little irrelevant, a little boring. Yet a closer look reveals that science and math are everywhere in the world around you, in familiar and surprising ways.

Take something fun, like the game of golf. Sure, there's math, because you have to keep score. But there's also lots of science, technology, and engineering hidden in the game — from the physics of how you swing, to the mechanics of a golf club, to the remote sensors that tell you when to water the golf course.

At the United States Golf Association Test Center, scientists and engineers play around with golf balls, clubs, and other equipment every day so that they can learn more about how they work. Since people keep thinking of new ways to improve the game, the USGA needs to constantly test new equipment to make sure it doesn't interfere with the game's best traditions or make game play unfair.

How does the USGA Test Center study this stuff? With golf ball cannons, robot clubs, and other cool experiments. And now you can do some of the very same experiments with the **TEST LAB TOOLKITS**, which let you set up your own test center in your club, class, or at home.

In this Toolkit, you'll explore the science behind the **WATER** through activities that let you:

1. **Experiment with evaporation and transpiration (and learn how they affect a golf course)**
2. **Investigate different kinds of soil (and discover which captures or loses the most water)**
3. **Design your own golf course (and figure out how to give it the water it needs)**
4. **Measure water use in your own home (and come up with easy water conservation strategies)**

For every experiment you try, record your results with photos, diagrams, or any way you like, and then put it all together into your own Test Lab Log. The more Toolkits you do, the more of a golf (and science) expert you'll become!

Ready to explore the science and math behind the world's greatest game?

Investigate: Evapotranspiration

Water

Grades 9-12

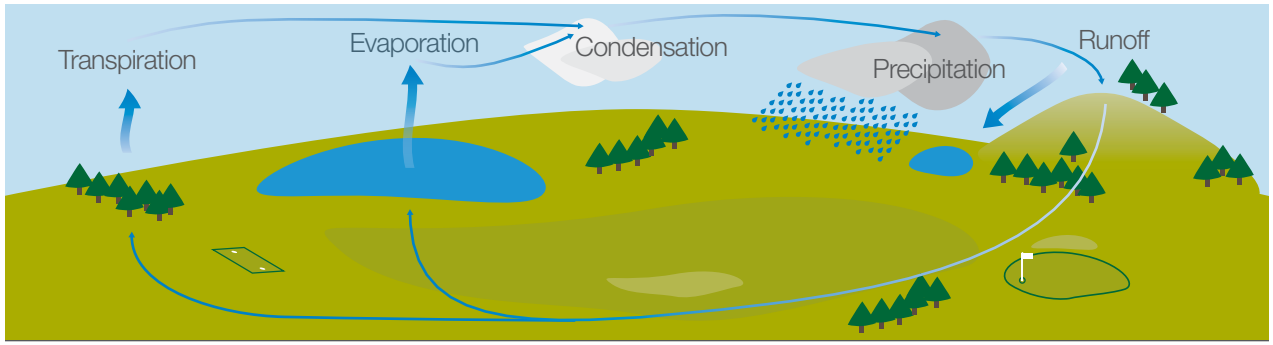
S T E M

How does water change from a liquid to a gas?

In addition to testing golf equipment, the USGA also promotes **environmental sustainability** on golf courses by studying how to keep courses beautiful and healthy, while conserving resources. One of the most important resources is water. To be able to conserve it, knowing when you need to irrigate and when you don't, you have to understand the **water cycle.** In this activity, you'll investigate the phase of the water cycle called **evapotranspiration** — the double process of **evaporation** from land and **transpiration** (breathing out water vapor) by plants.

What Do You Need?

- 4 sponges
- 4 plates
- Water
- Measuring cup
- 4 small or medium-size potted plants
- 4 clear plastic bags
- String
- Portable fan (optional)



Water Cycle

What Do You Do?

1 Put each sponge on a plate. Pour ¼ cup water on each.

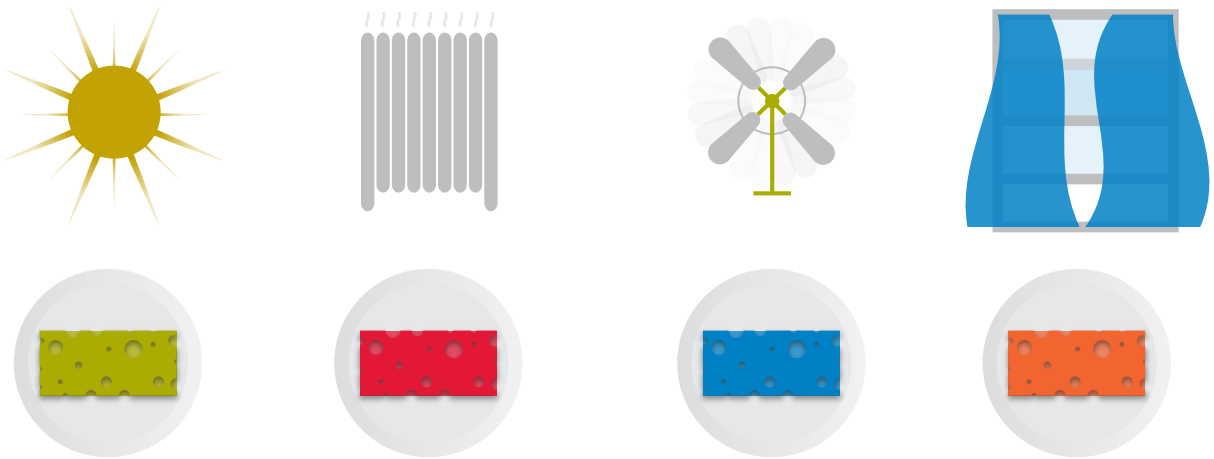
2 Find 4 plants, preferably the same kind. Put a plastic bag over a big leaf or a small branch of each plant, about the same size. Tie the bags closed with string.

3 Put one plate and one plant in each of the following places:

- In front of a sunny window (closed)
- In a breeze (in front of a fan or by an open window)
- In a warm place (near a radiator, in the kitchen, etc.)
- In a dark corner

4 Let everything sit for 30 minutes. When you come back, which sponges are drier? What is happening inside the bags?

5 Check again after another 30 minutes, or an hour, or a day.



What Happens?

Use the chart to record your results, and make more as needed.

What Does it Mean?

- What did you learn about evaporation and transpiration?
- Which sponge dried the fastest? Which plant transpired the most?
- How do you think evapotranspiration would affect a golf course?

Challenge!

Do the same experiment outside, by putting sponges and wrapping plants in different locations (sunny, shady, windy, etc.).

Find Out More

- Read *Key Concepts* at the back of this Toolkit.
- Read *Water: Background Information.*
- Watch the NBC Learn video "Water Conservation" at www.nbclearn.com/science-of-golf.

	Location	What Happens After 30 Minutes?	After 1 Hour?	After 1 Day?
Sponges	Sunny Window	*Very damp*	*Drier*	*Totally dry*
	Breeze			
	Warm Place			
	Dark Corner			
Plants	Sunny Window			
	Breeze			
	Warm Place			
	Dark Corner			

Add this chart to your Test Lab Log!

Investigate: Water Retention

Water

Grades 9-12

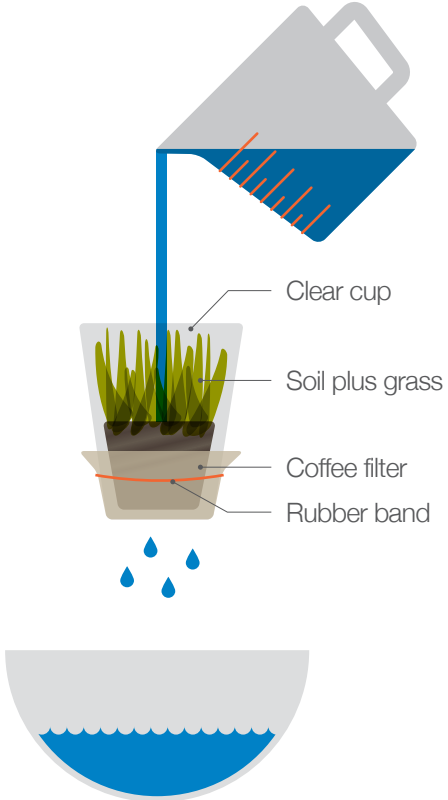
S T E M

How can you tell how much water different kinds of soil capture?

On a golf course, turfgrass plays an important role in **water retention.** By looking at how much water the course "captures" through natural sources (such as **rainfall**) and how much it loses (through **runoff**), you can figure out how much is retained and how much needs to be replaced through **irrigation.** The USGA studies the water retention of different turfgrasses to help golf course managers make the best selections. In this activity, you'll explore how well turfgrass holds onto water compared to other soils.

What Do You Need?

- 4 plastic cups
- 1 sample of turf (grass plus soil), about 4 inches deep
- 3 different samples (sand, gravel, soil without grass, etc.) each about 4 inches deep
- 4 paper coffee filters
- 4 rubber bands
- Bowl
- Scissors
- Measuring cup
- Water
- Scale (optional)



This activity is adapted from NBC Learn: Science of Golf, "Water Conservation"

What Do You Do?

1. Collect the turf and soil samples from your local park, backyard, garden store, etc.
2. Cut off the bottom of each cup. Place each cup inside a coffee filter and attach it with a rubber band.
3. Put a turf or soil sample in each cup, about 4 inches deep. If you want to be precise, you can weigh each cup with sample. Label the different samples.
4. Hold a cup over a bowl and pour in 6 oz of water.
5. When water stops dripping out of the cup's bottom, pour the water in the bowl back into a measuring cup. Record the amount on Chart 1.
6. If you have a scale, weigh the cup again and record the new amount.
7. Repeat steps 4-6 with the other cups.
8. Now imagine that your turf sample is used for an actual golf course. Use Chart 2 to calculate the water requirement per acre (amount of irrigation needed). First find the **runoff** and **water deficit** for each month.
9. Then use the water deficit to calculate the **water requirement per acre.** How much water do you need to irrigate each turf annually?

◀ **Different types and cuts of turf at Harbour Trees Golf Club**

Challenge!

Try this experiment with common turfgrasses used on golf courses, such as bent grass, bermudagrass, or Kentucky bluegrass. You can ask your local golf course for samples, or grow them from seed.

What Happens?

Use the charts to record your results, and make more as needed.

What Does it Mean?

- What did you learn about water retention?
- Which type of soil retained the most water and why?
- How do you think turfgrass affects a golf course?

Find Out More

- Read *Key Concepts* at the back of this Toolkit.
- Read *Water: Background Information.*
- Watch the NBC Learn video "Water Conservation" at www.nbclearn.com/science-of-golf.

Chart 1. How much water does each turf retain?

	Water Added ounces	**Water Lost (runoff)** ounces	**Water Lost (runoff)** percent	**Water Retained** ounces	**Water Retained** percent	**Weight Before Water** pounds	**Weight After Water** pounds
Turf (soil plus grass)	*6*	*3*	*50%*	*3*	*50%*	*.2*	*.3*
Soil only							
Sand							
Gravel							

Add this chart to your Test Lab Log!

Chart 2. How much would you need to irrigate?

Turf #	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
Evapotranspiration (inches)	3.0	3.0	4.5	6.0	7.0	7.0	7.0	7.0	6.0	6.0	4.5	3.0	
Rainfall (inches)	3.0	3.2	2.7	4.0	4.2	3.3	2.7	2.5	3.0	2.7	3.3	3.5	
Runoff (inches) Calculate with runoff percent for turf sample (Chart 1)	*1.5*												
Water Deficit (inches)	*1.5*												
Water Requirement (inches)	*1.05*												
Water Requirement per Acre (gallons)	*28509.6*												

Formulas for Chart 2

Runoff = rainfall x runoff percent [from Chart 1]

Water deficit = evapotranspiration – (rainfall – runoff)

Water requirement = .70 x water deficit

Water requirement per acre (gallons) = water requirement (inches) x 27,152 (gal/inch-acre)

Create: Golf around the World

Water

Grades 9-12

S T E M

How would you design a golf course for a different environment?

How much water a golf course needs depends a lot on **local climate.** For example, a golf course in a desert climate may need more or less water than one in New England, depending on the type of **turfgrass** used. That's why the USGA Green Section recommends using turfgrass adapted to the natural environment.

In this activity, you'll design your own golf course and think about how much water you would need (and how you would supply it) to keep the course healthy.

What Do You Need?

- Computer
- Paper and markers
- OR foam board and craft materials

▼ **Pebble Beach Golf Links (coastal golf course)**

What Do You Do?

1. Pick a location somewhere in the world for your golf course. Research its biome (climate, rainfall, temperature, vegetation, etc.) at earthobservatory.nasa.gov/Experiments/Biome or elsewhere.

2. Decide how your course will compare to its natural environment. Will it use the same kinds of terrain, vegetation, and water features, or will you create a different environment? For example, you could design a grasslands course in a grasslands environment, or a grasslands course in a desert environment.

3. Create at least one hole of your golf course on paper or with craft materials, showing vegetation and water sources, as well as the surrounding natural environment.

4. Based on your research, estimate whether your course will need a little or a lot of water. How much will be available from rainfall and onsite water sources? How much irrigation will be necessary? A course that uses plants adapted to the natural environment may need less irrigation.

5. Compare your course with the ones your friends made. Which ones need the most and least water?

◀ **Desert Forest Golf Club (desert golf course)**

What Happens?

Compare golf courses and note the results.

What Does it Mean?

- How does the local environment affect water needs?

- What did you learn about golf course design?

Find Out More

- Read *Key Concepts* at the back of this Toolkit.

- Read *Water: Background Information.*

- Watch the NBC Learn video “Water Conservation” at www.nbclearn.com/science-of-golf.

Connect: Water in Your Home

Water

Grades 9-12

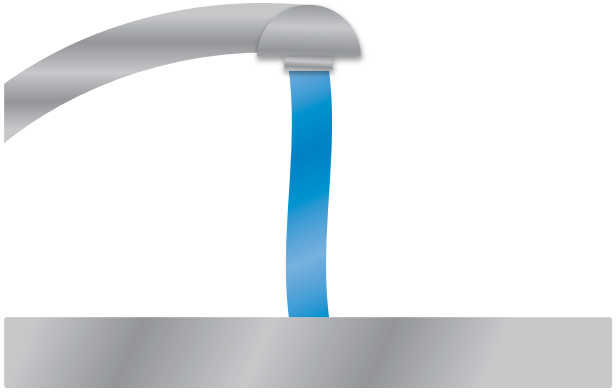
S T E M

How can you conserve water at home?

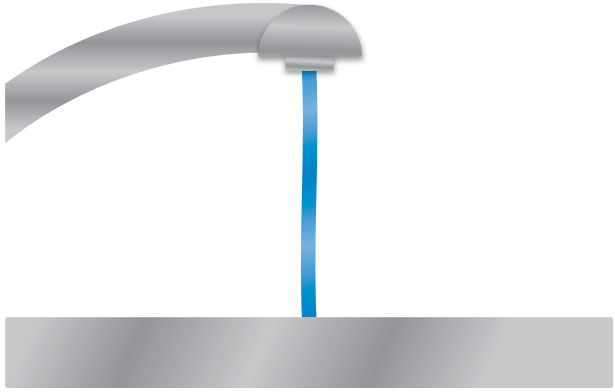
The USGA Green Section helps golf course managers maintain courses so that they conserve water as much as possible. But **water conservation** isn't just an important issue on a golf course — it's important throughout the world, including in your own home. In this activity, you'll explore how much water you use at home, and think about ways to conserve it.

What Do You Need?

- Chart
- Pencil
- Stopwatch



Full on



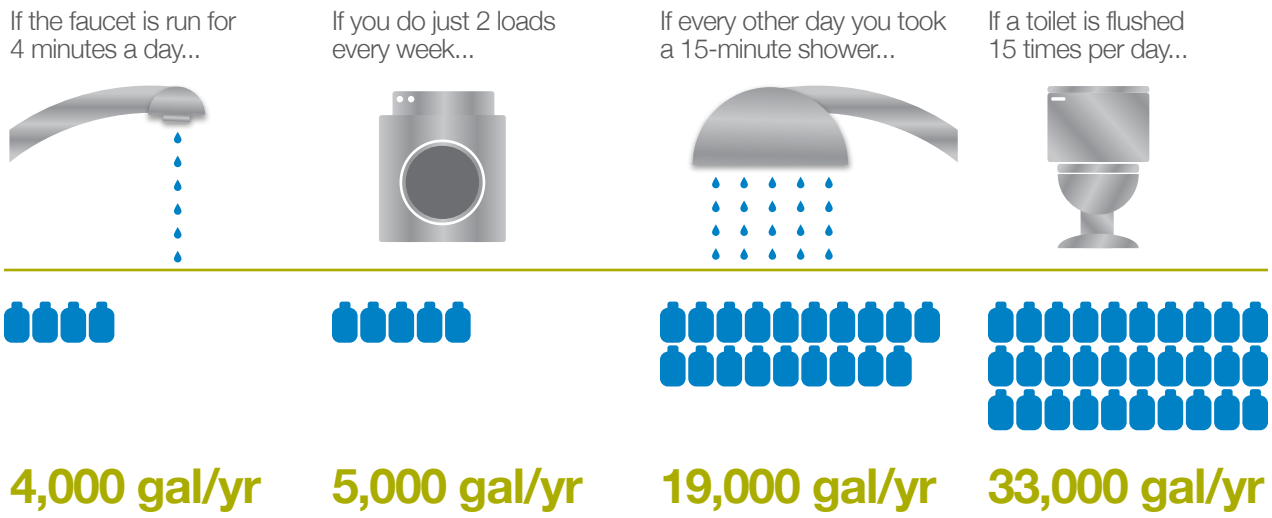
Half on

Dripping

This activity is adapted from the Three Actions Project (www.threeactionsproject.org/Actions/Track-Your-Daily-Water-Use.php)

What Do You Do?

1. Use the chart to calculate how much water you (or your entire family) use in a week. Record **how many times** you do each of the activities each day.
2. At the end of the week, **add up the total** for each activity and **multiply** by the Average Water Usage.
3. Compare your results with friends. Who had the lowest and highest weekly water consumption? Why?
4. Brainstorm ways to conserve water at home. Check out www.threeactionsproject.org/Actions for ideas.
5. You can also work with friends to figure out how much water your golf course or school uses.



This chart is adapted from eLocal.com (http://www.elocal.com/content/home-expert-network/water-home-wasting-infographic-431)

What Happens?

Use the chart to record your results, and make more as needed.

What Does it Mean?

- What did you learn about your water consumption?
- What are some ways to conserve water at home?

Find Out More

- Read *Key Concepts* at the back of this Toolkit.
- Read *Water: Background Information.*
- Watch the NBC Learn video "Water Conservation" at www.nbclearn.com/science-of-golf.

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Total for Week	Average Water Usage gallons	Total Water Usage gallons
Toilet flush									x 3.5	
Wash hands (half-on)									x .25	
Wash face (half-on)									x .5	
Brush teeth (half-on)									x .5	
Shower (10 min)									x 20	
Kitchen faucet (1 min)									X .5	
Wash Dishes by hand (fill basin)									x 10	
Dishwasher									x 12	
Washing machine									x 42	
Lawn sprinkler (5 min)									x 10	
									Total Weekly Water Usage	

This activity is adapted from the Three Actions Project (www.threeactionsproject.org/Actions/Track-Your-Daily-Water-Use.php)

Add this chart to your Test Lab Log!

Key Concepts

Agronomist
A scientist who specializes in turf and soil management.

Condensation
The conversion of water from a gas or vapor to a liquid due to cooling.

Evaporation
The conversion of water from a liquid to a gas or vapor due to heat. Water can evaporate from both soil and bodies of water (lakes, rivers, oceans).

Evapotranspiration (ET)
The combined processes of evaporation and transpiration. Golf course managers use this term to refer to the total loss of liquid water from a course via both evaporation and transpiration.

Humidity
The amount of moisture in the air. Even in the desert, the air always contains water vapor that has evaporated from land and water sources, or transpired from plants.

Irrigation
To apply water to the land via artificial means (such as a sprinkler) rather than natural means (such as rainfall). Irrigation is used on golf courses and farms when water from natural sources isn't enough for healthy plant growth.

Precipitation (Rainfall)
The process by which water vapor in the air condenses to a liquid and falls to the ground as rain. Precipitation can also take a solid form (hail, sleet, or snow).

Runoff
Water that flows away from the soil surface, often into a nearby body of water (river, pond, etc.), rather than being absorbed by the soil. To figure out the water deficit of a golf course and how much to irrigate, managers need to know how much rainfall is lost to runoff.

Salinity
The salt content of a substance. Excessive salinity in the soil slows down the growth of turfgrass.

Transpiration
The movement of water through a plant from the moment it's absorbed by the roots until it's released as a gas through the plant's leaves.

Turfgrass

A variety of grass used to grow turf (outdoor playing surfaces), for sports like golf or baseball. Different types of turfgrass are well-suited to different climates and seasons. Warm-season grasses (such as such as bermudagrass and buffalograss) require less water than cool-season grasses (such as Kentucky bluegrass and tall fescue).

Water Conservation

The effort to protect the purity of water sources, reduce the need of environments and populations for water, and use water as efficiently as possible with little waste. Water conservation is an important issue in many areas of the world where water quality and quantity are both at risk.

Water Cycle (Hydrologic Cycle)

The natural process by which water constantly changes its state and moves from the surface of the Earth into the atmosphere (via evaporation and transpiration), and then back to the surface again (via precipitation).

Water Deficit

On a golf course, the amount of rainfall that is lost to evapotranspiration and runoff, instead of being retained by the soil.

Water Retention

The ability of an object or surface (like turfgrass) to retain water.

Water Requirement

The amount of water that needs to be applied to a golf course through irrigation, in order to make up for the water deficit.