The Science of Golf

Test Lab Toolkit
The Course: Water

Grades 9-12
## Table of Contents

Welcome to the Test Lab 02  
Investigate: Evapotranspiration 03  
Investigate: Water Retention 06  
Create: Golf around the World 10  
Connect: Water in Your Home 12  
Key Concepts 15  

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).
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?
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)
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.
# Investigate: Evapotranspiration

## Grades 9-12

### 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

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?

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.

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.

Different types and cuts of turf at Harbour Trees Golf Club

Copyright USGA/Kirk H. Owens
<table>
<thead>
<tr>
<th>Water Added ounces</th>
<th>Water Lost (runoff) ounces</th>
<th>Water Lost (runoff) percent</th>
<th>Water Retained ounces</th>
<th>Water Retained percent</th>
<th>Weight Before Water pounds</th>
<th>Weight After Water pounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turf (soil plus grass)</td>
<td>6</td>
<td>3</td>
<td>50%</td>
<td>3</td>
<td>50%</td>
<td>.2</td>
</tr>
<tr>
<td>Soil only</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sand</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gravel</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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)

---

**Chart 2. How much would you need to irrigate?**

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

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.
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

---

**Connect: Water in Your Home**

**How can you conserve water at home?**

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](http://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.

**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**.

---

**Connect: Water in Your Home Grades 9-12**

<table>
<thead>
<tr>
<th>Activity</th>
<th>Water Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>If the faucet is run for 4 minutes a day</td>
<td>4,000 gal/yr</td>
</tr>
<tr>
<td>If you do 2 loads every week</td>
<td>5,000 gal/yr</td>
</tr>
<tr>
<td>If every other day you took a 15-minute shower</td>
<td>19,000 gal/yr</td>
</tr>
<tr>
<td>If a toilet is flushed 15 times per day</td>
<td>33,000 gal/yr</td>
</tr>
</tbody>
</table>

This chart is adapted from eLocal.com ([http://www.elocal.com/content/home-expert-network/water-home-wasting-infographic-431](http://www.elocal.com/content/home-expert-network/water-home-wasting-infographic-431))
<table>
<thead>
<tr>
<th>Activity</th>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
<th>Friday</th>
<th>Saturday</th>
<th>Sunday</th>
<th>Total for Week</th>
<th>Average Water Usage gallons</th>
<th>Total Water Usage gallons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toilet flush</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x 3.5</td>
<td></td>
</tr>
<tr>
<td>Wash hands (half-on)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x .25</td>
<td></td>
</tr>
<tr>
<td>Wash face (half-on)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x .5</td>
<td></td>
</tr>
<tr>
<td>Brush teeth (half-on)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x .5</td>
<td></td>
</tr>
<tr>
<td>Shower (10 min)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x 20</td>
<td></td>
</tr>
<tr>
<td>Kitchen faucet (1 min)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X .5</td>
<td></td>
</tr>
<tr>
<td>Wash Dishes by hand (fill basin)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x 10</td>
<td></td>
</tr>
<tr>
<td>Dishwasher</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x 12</td>
<td></td>
</tr>
<tr>
<td>Washing machine</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x 42</td>
<td></td>
</tr>
<tr>
<td>Lawn sprinkler (5 min)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x 10</td>
<td></td>
</tr>
</tbody>
</table>

**Total Weekly Water Usage**

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

*Add this chart to your Test Lab Log!*
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.
### Key Concepts

#### 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 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.