

# The Science of Golf

## Test Lab Toolkit **The Swing: Putting**

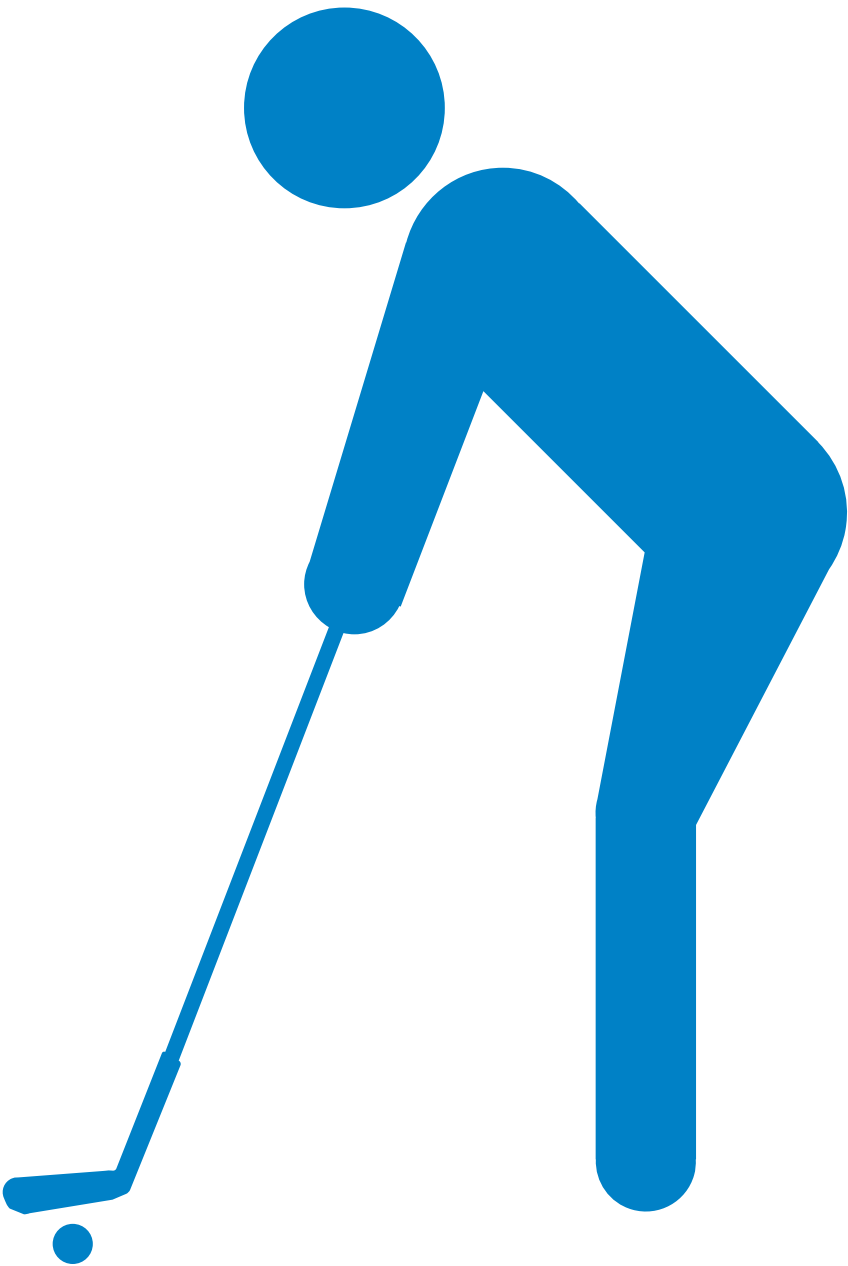
Grades 9-12



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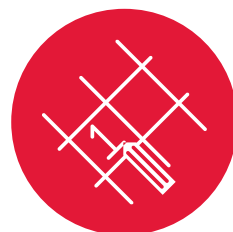
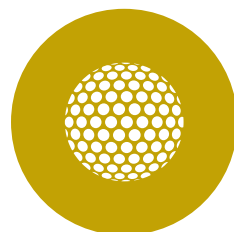
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Test Lab Toolkits bring math and science to life by showing how STEM studies play a big role in the game of golf. They are funded by the United States Golf Association (USGA).



# Welcome to the Test Lab Toolkit!

## Putting



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 the golf course needs to be watered.

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 of **PUTTING** through experiments that let you:

- 1 **Make the golf ball “break” (and see that a curve is sometimes the straightest path)**
- 2 **Build a Stimpmeter (and learn what that thing is even used for)**

- 3 **Design your own putting green (and find out what makes it more or less challenging)**

- 4 **Measure the speed of your local golf course (and discover why the ball rolls faster on some putting greens than others)**

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 behind the world's greatest game?

# Investigate: Gravity on the Green

Putting



Grades **9-12**



## Is a straight line always the best path to the hole?

Putting greens may appear flat, but most have undulations that prevent a ball from rolling straight. Gravity always pulls the ball downward, so the putter must make the ball curve, or break, toward the hole. In this activity, you will explore how clubface angle, aim, and swing speed make the ball move.

## What Do You Need?

Large plastic cup

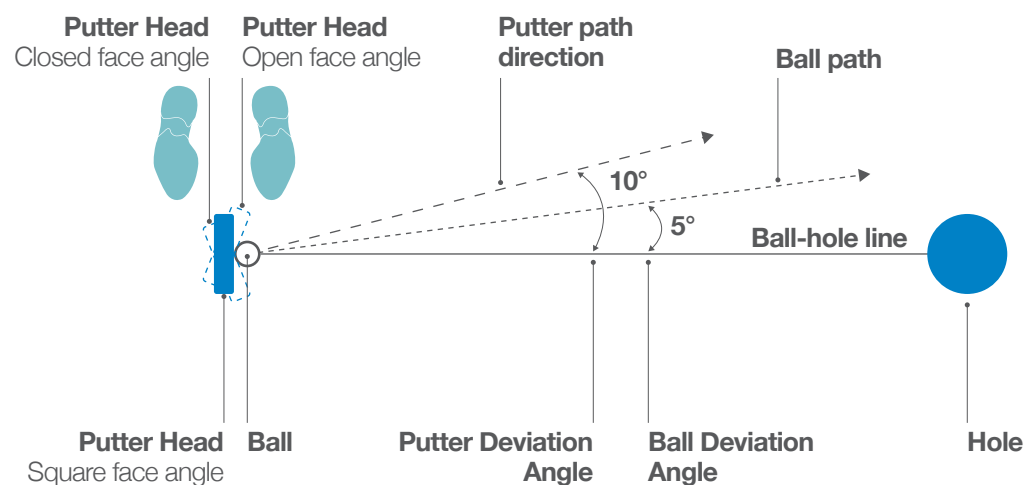
Masking tape

Putter (or stick of similar length)

Golf ball (or similar small ball)

Rope or string

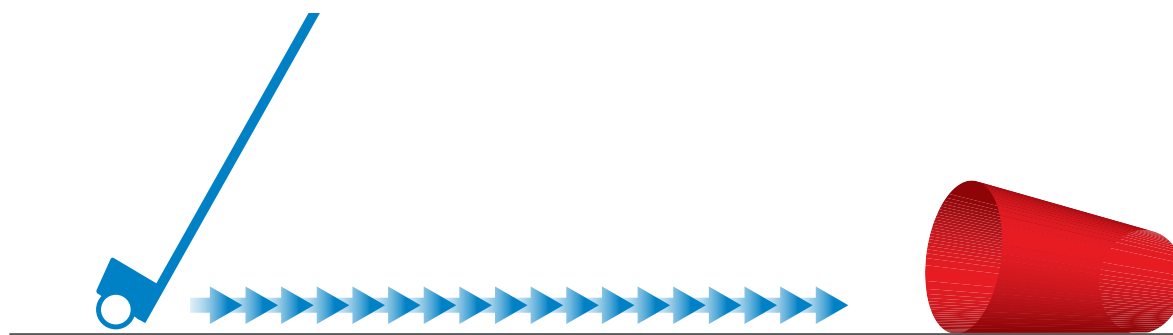
Protractor





## What Do You Do?

- 1 Locate a level surface at least 10 feet in diameter. In the middle, set up a target by lying the cup on its side and taping it to the floor. Around the outside of the space, mark units like a clock-face.
- 2 Stand 5 feet away from the cup, at the “noon” position. Imagine a straight line from your ball to the cup (the ball-hole line).
- 3 Putt the ball directly along the ball-hole line, with the clubface perpendicular to your body and medium speed.
- 4 Mark the spots where the putter and ball stop with tape. Use 2 pieces of long string and a protractor to determine the angle of deviation of the putter's path (based on its end position) from the ball-hole line, and the angle of deviation of the ball's end point from the ball-hole line (if it missed the cup). Record your results.



- 5 Repeat with different combinations of swing speed (slow, medium, fast), aim (straight, to the left, to the right), clubface angle (square, open, closed), and position (3 o'clock, 6 o'clock, etc.).
- 6 For each variation, predict what will happen and then record what did happen.

### Challenge!

Do this experiment on a sloped surface, and try standing at the top, at the bottom, or to the side of the slope. How do you need to adjust your clubface angle, aim, and swing speed to compensate for the slope?

## What Happens?

- Use the chart to record your data and make more charts as needed.
- Diagram your data, using the illustration as a model. For each variation, show the ball-hole line, the initial and end points of the putter and ball, and their paths and angles of deviation.

## What Does it Mean?

- What did you learn about the speed and the path of the ball?
- Which combination of clubface angle, aim, and speed is most successful at hitting the ball into the cup?

## Find Out More

- Read *Key Concepts*.
- Watch the NBC Learn video “Kinematics” at [www.nbclearn.com/science-of-golf](http://www.nbclearn.com/science-of-golf).



Position	Clubface Angle	Swing Aim	Swing Speed	Putter Path Angle of Deviation	Ball Angle of Deviation
12 o'clock	square	straight	medium	10°	5°

 Add this chart to your Test Lab Log!

# Investigate: Speed and Friction

Putting



Grades **9-12**



## Why does your putt roll fast or slow?

On a putting green, it isn't just how hard you swing that matters. It's also the **speed of the green** — how far and fast the ball rolls before friction slows it down. The USGA Test Center uses a **Stimpmeter** to measure green speeds. In this activity, you'll build your own Stimpmeter and try it out.

## What Do You Need?

2 narrow pieces of firm material at least 36 inches long, such yardsticks or cardboard

Tape or glue

Scissors or marker

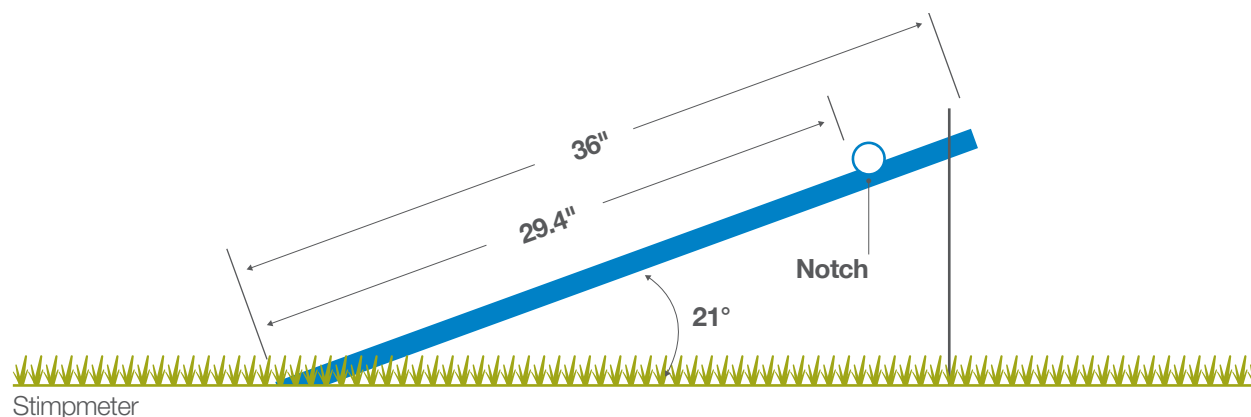
Protractor

Tape measure

Golf ball, plus at least two other types of small balls (ping pong ball, hard rubber ball, etc.)

At least three different surfaces to test on (grass, astroturf, carpeting, cement, wood, etc.)

Stopwatch



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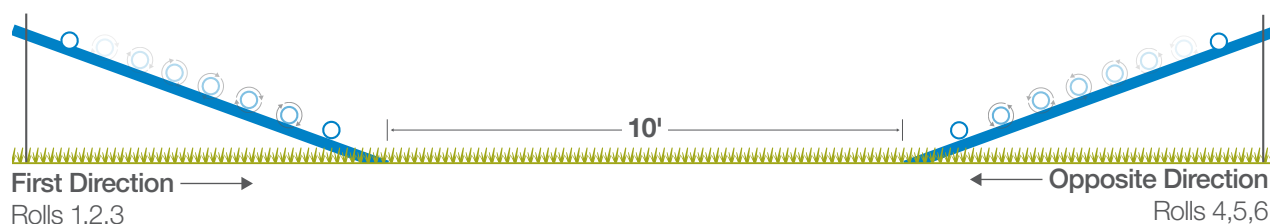


This activity is adapted from NBC Learn, *Science of Golf: Kinematics* (<http://www.nbclearn.com/science-of-golf>)



## What Do You Do?

- 1 Build a Stimpmeter. Hold two pieces of firm material together length-wise, so they form a v-shaped channel. Tape or glue them. Cut a notch (or mark a spot) at 29.4 inches from the end.
- 2 Stand on a level surface, at least 15 feet long. Face the center.
- 3 Using the protractor, raise the notched end of the Stimpmeter to 21 degrees. Release the ball from the notch. Record how far and long it rolls from the END of the Stimpmeter until it stops.
- 4 For each experiment, follow these steps:
  - Roll the ball 3 times in one direction. Average the results.
  - Walk to where the ball stopped rolling and turn around to face your starting position.
  - Now roll the ball 3 times in the **opposite direction**. Average the results.
  - Calculate the combined average.
- 5 Test how a ball rolls across at least 3 **different surfaces**. Calculate time and distance averages for each surface, and average rates of deceleration (assuming the standard speed from the end of the Stimpmeter is 6.4 feet/sec).
- 6 Test how at least 3 **different balls** roll across the same surface. Calculate time and distance averages for each ball, and average rates of deceleration.
- 7 Roll a ball across the same surface with the Stimpmeter at 3 **different angles**. Calculate time and distance averages for each angle, rates of acceleration along the Stimpmeter, speeds at the end of it, and rates of deceleration.



## Formulas

- **Velocity** = distance/time
- **Acceleration rate** = (final velocity at end of Stimpmeter – starting velocity at release point) / time to travel to end of Stimpmeter
- **Deceleration rate** = (final velocity at rest – starting velocity at end of Stimpmeter) / time to travel from Stimpmeter to complete stop

## What Happens?

- Use the chart to record your data and make more charts as needed. For the surface and ball experiments, graph deceleration rates.
- For the angle experiment, make a speed-versus-time graph that shows the changing speed of the ball from (A) point of release to (B) top speed at the end of the Stimpmeter to (C) state of rest.

## What Does it Mean?

- Which experiment had the fastest green? The slowest?
- What did you learn about friction and speed?





## Challenge!

Calculate the speed of a single ball across a single surface with a small slope. Follow the standard steps, rolling the ball first uphill and then downhill. If  $S \uparrow$  is the average distance of the uphill rolls and  $S \downarrow$  is the average distance of the downhill rolls, use this formula to find the speed of the sloped green:

$$\frac{2 \times S \uparrow \times S \downarrow}{S \uparrow + S \downarrow}$$

## Find Out More

- Read *Key Concepts*.
- Watch the NBC Learn video “Kinematics” at [www.nbclearn.com/science-of-golf](http://www.nbclearn.com/science-of-golf).



Chart 1

Surface	Distance: Starting Direction feet				Distance: Opposite Direction feet				Overall Distance Average Speed of the Green feet
	Roll 1	Roll 2	Roll 3	Average	Roll 4	Roll 5	Roll 6	Average	
Grass	6	5	7	6	5	7	5	5.6	5.8

Chart 2

Surface	Time to Travel to End of Stimpmeter seconds						Average Time seconds	Velocity at End of Stimpmeter feet/second	Acceleration Rate feet/second <sup>2</sup>
	Roll 1	Roll 2	Roll 3	Roll 4	Roll 5	Roll 6			

Chart 3

Surface	Time to Travel to End of Stimpmeter To Complete Stop seconds						Average Time seconds	Velocity at End of Stimpmeter feet/second	Deceleration Rate feet/second <sup>2</sup>
	Roll 1	Roll 2	Roll 3	Roll 4	Roll 5	Roll 6			



Add these charts to your Test Lab Log!

# Create: Putting Green

Putting



Grades **9-12**



## What makes a putting green challenging, but not impossible?

The USGA Test Center helps golf courses make sure that putting greens challenge the skill level of the players, but aren't unfair. In this activity, you'll use what you've learned about **friction**, **speed**, and **angles** to create your own putting green — and then compete with your friends in a tournament!

## What Do You Need?

Paper

Pens

Materials for the green surface  
(astroturf, cardboard, fabric, etc.)

Materials to create hazards  
(water, sand, etc.)

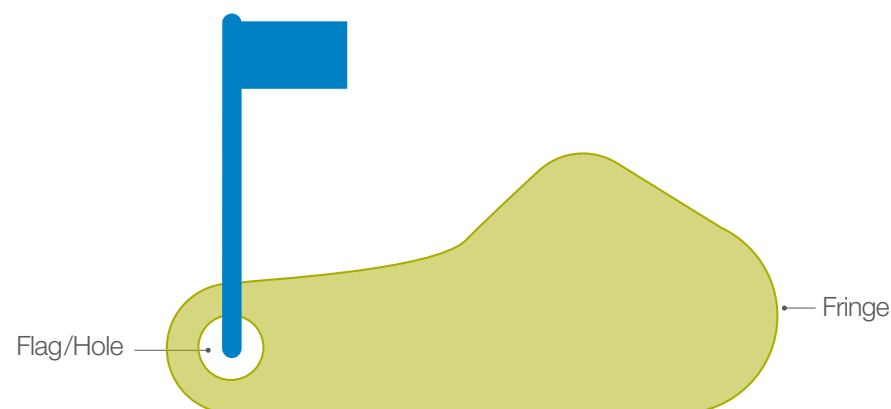
Scissors

Large plastic cup  
(one per hole)

Masking tape

Putter (or stick of similar length)

Golf ball (or similar small ball)



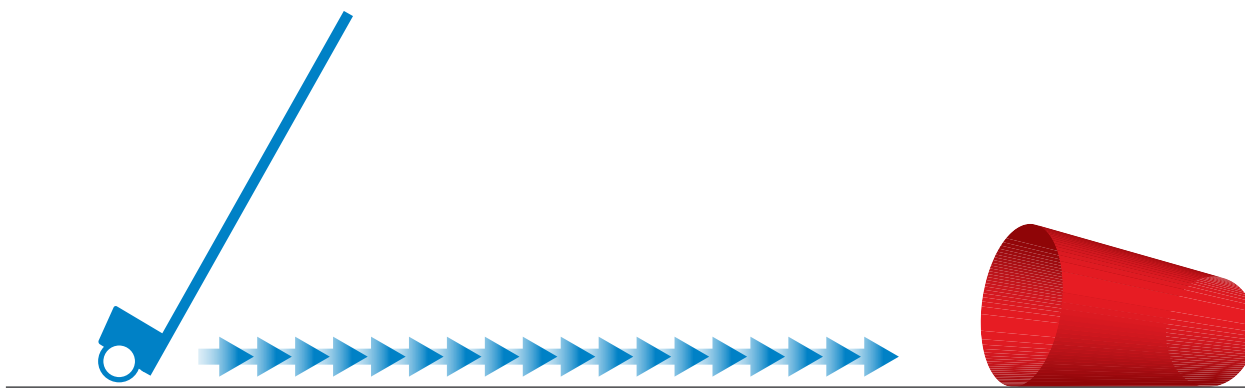
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## What Do You Do?

- 1 Find a large space where you can create one or more putting greens.
- 2 Design them first on paper, including shape, hole size and placement, and standard golf course hazards (sand pit, water, etc.). Think about what would make a green harder or easier — faster isn't necessarily better.
- 3 Build the putting green(s) out of available materials, taping down one cup per hole for the target.
- 4 Have everyone play each putting green once. Record the scores. For each hole, calculate the average of the top half of the scores (the "better half" average). You can use this average as par.
- 5 Have a tournament. Invite friends to play also!



## What Happens?

- Record your scores.
- Note the results, including diagrams and/or photos of the putting greens.

## What Does it Mean?

- How did what you know about friction, speed, and angles influence your design?
- What is the best strategy for playing each hole, and why?

## Find Out More

- Read *Key Concepts*.
- Watch the NBC Learn video "Kinematics" at [www.nbclearn.com/science-of-golf](http://www.nbclearn.com/science-of-golf).

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**Add this chart to your Test Lab Log!**

# Connect: Your Local Golf Course

Putting



Grades **9-12**



## How fast is your local golf course?

The putting green speed of American golf courses ranges from 7 to 12 feet. How does your own local golf course compare? In this activity, you'll use a Stimpmeter to find out!

## What Do You Need?

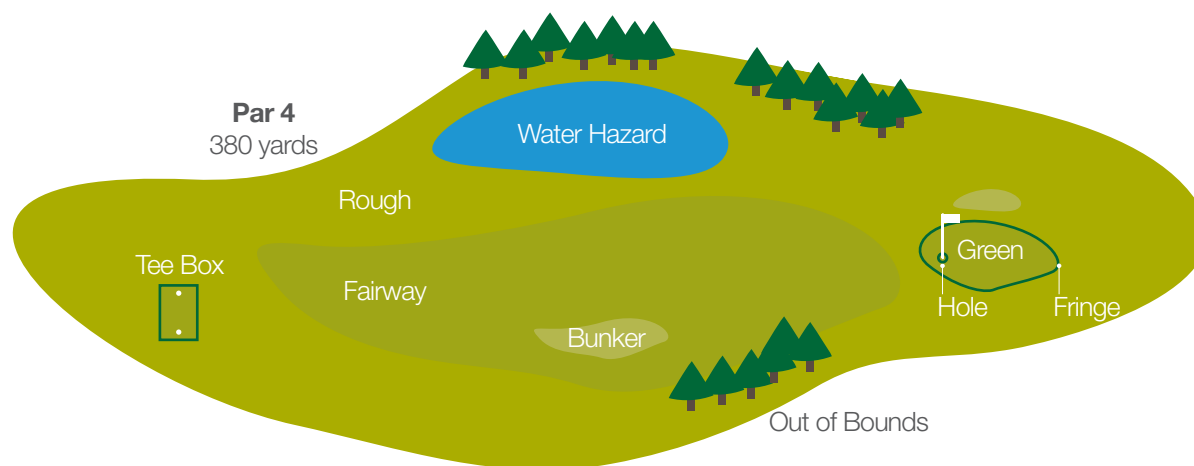
2 narrow pieces of firm material at least  
36 inches long, such yardsticks  
or cardboard  
Tape or glue  
Scissors or marker

Protractor

Tape measure

Putter

Golf ball





## What Do You Do?

- 1 Build a Stimpmeter. Hold two pieces of firm material together length-wise, so they form a v-shaped channel. Tape or glue them. Cut a notch (or mark a spot) at 29.4 inches from the end. You can skip this step if you have already built one.
  - 2 Find a nearby golf course. Ask them if it's ok to do your experiment.
  - 3 For each putting green on the course, follow these steps:
    - Find a level area on the green.
    - Using the protractor, raise the notched end of the Stimpmeter to 21 degrees. Release the ball from the notch. Record how far and long it rolls from the END of the Stimpmeter until it stops.
    - Roll the ball 3 times in one direction. Average the results.
  - 4 Once you know the speed of the greens, play a full round, and figure out the best strategy for each hole based on how fast or slow it is.
- Walk to where the ball stopped rolling and turn around to face your starting position.
  - Now roll the ball 3 times in the **opposite direction**. Average the results.
  - Calculate the combined average.

## What Happens?

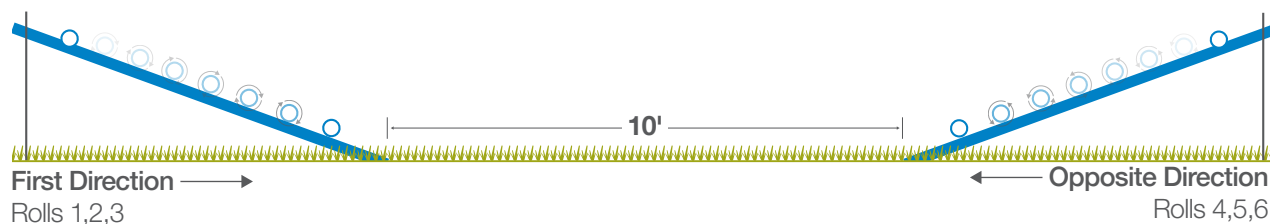
- Use the chart to record your data.
- Note the results, including diagrams and/or photos, and share them with the golf course, friends, and family.

## What Does it Mean?

- What did you learn about the putting greens on your local golf course?
- What is the best strategy for playing each hole, and why?

## Find Out More

- Read *Key Concepts*.
- Watch the NBC Learn video "Kinematics" at [www.nbclearn.com/science-of-golf](http://www.nbclearn.com/science-of-golf).





Hole	Distance: Starting Direction feet				Distance: Opposite Direction feet				Overall Distance Average Speed of the Green feet
	Roll 1	Roll 2	Roll 3	Average	Roll 4	Roll 5	Roll 6	Average	
	6	5	7	6	5	7	5	5.6	5.8

 Add this chart to your Test Lab Log!



# Key Concepts

Putting



## Acceleration

The increase of an object's velocity over time.

$$A = (V2 - V1) / (T1 - T2)$$

## Breaking on the Green

The way a golf ball curves (or breaks) toward the hole, due to the slope of the green and gravity.

## Deceleration (Negative Acceleration)

The decrease of an object's velocity over time.

$$D = (V2 - V1) / (T1 - T2)$$

## Friction

A force between objects moving in different directions, when their surfaces touch each other and oppose each other's motion.

## Gravity

A force of attraction that pulls objects toward each other. The more mass an object has, the stronger its gravitational pull.

## Kinematics

A branch of classical mechanics in the science of physics that describes motion through position, velocity, and acceleration.

## Position

The place where an object is located.

## Read the Green

To look carefully at the shape, slope, grass, etc., of a putting green to figure out the best way to putt a golf ball into the hole.

## Speed

The measure of how fast an object travels a specific distance over a specific time.

$$S = D / T$$

## Speed of the Green

How fast or slow the ball moves across a putting green.

## Stimpmeter

A simple device that rolls a golf ball onto a putting green at a fixed speed, so that you can measure how fast or slow the green is.

## Velocity

The measure of speed in a specific direction.