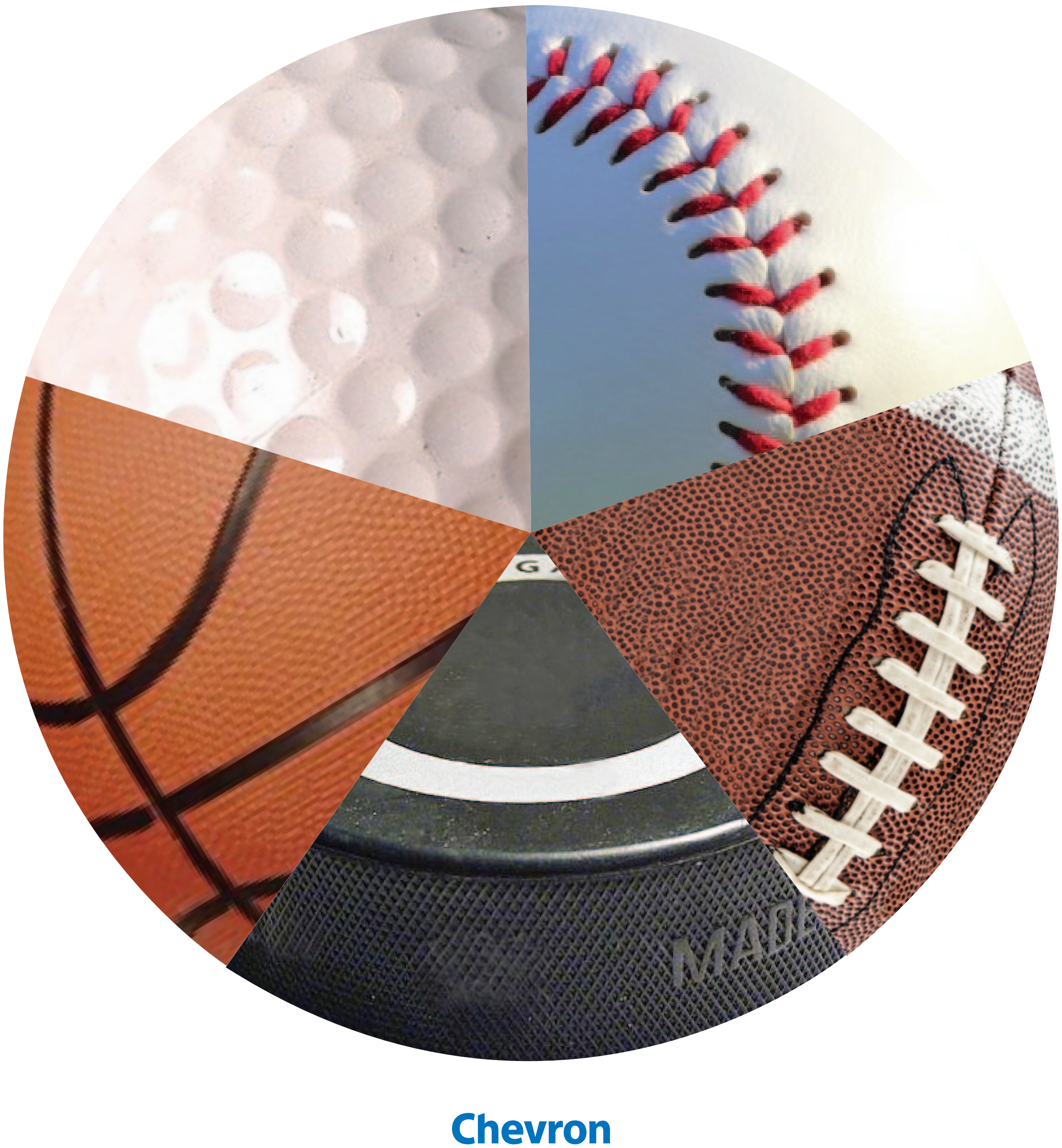
TEACHER GUIDE

GAME ON!
Sports in the STEM Zone



Chevron

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This teacher guide and the student supplement were created by Kid Scoop. For more about Kid Scoop go to www.kidscoop.com.

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INTRODUCTION

LETTER TO TEACHERS

Dear Educator,

Science, technology, engineering and mathematics – known as STEM – are as important to sports as slam dunks, touchdowns, goals, home runs or a hole-in-one. Students are naturally curious about the way things work around them – and they love to play games! *Game On!* combines both interests and shows students how science, technology, engineering and math provide the power behind some of their favorite sports – baseball, football, hockey, basketball and golf.

To drive home the value of STEM in a student's education – and its potential impact on a career choice – Chevron Corporation uses sports to engage and excite students about their learning – and their futures. *Game On!* links STEM directly to a student's world. By providing a scientific lens focused on something fun – like sports – students can draw connections to their lives that are "real" and instructive!

Game On! introduces physical science and forces at play while playing. Understanding parabolic arcs and conservation of energy in the context of a basketball game contributes to deeper learning of concepts like motion, drag, lift and gravity. Chemistry and engineering contribute directly to technology that makes layers of ice safer for hockey players whizzing by. Baseball depends on mathematics for statistics and why hurling balls from the outfield at a just the right angle will get that last out. Learning why the quarterback's grip and spin on a "prolate spheroid" are critical to the game of football brings geometry to life. Swinging a club with just the right angle puts a scientific "spin" on golf!

Activities in *Game On!* are fully aligned with national common core standards in English language arts, mathematics and the Next Generation Science Standards. Each lesson provides students opportunities to read expository text, support claims by locating evidence, interpret data and master domain specific vocabulary while reading about games they love to play or watch. Each lesson encourages recording observations, data, or findings in a Science Notebook. Journaling information teaches students how to "write like a scientist" – an essential component of cross content skills in the common core. Options for notebooks might range from stapled pieces of paper to a composition book, spiral notebook, or even electronic record keeping through an online learning platform. Discussing ideas with partners, participating in experiments and solving problems help learners practice communication, collaboration, critical thinking and creativity – skills critical to success in college and careers of the 21st century.

We know teachers and students will love the science behind sinking a hockey goal, hitting a homerun, stuffing a slam dunk or scoring a touchdown. Science, technology, engineering and math are a winning combination whether on the field or in the classroom. So grab your favorite ball, bat, helmet, mitt or driver – because it's *Game On!*

STANDARDS

Reading Informational Text (RI):Gr.4-5; Speaking & Listening (SL):Gr.4-8		Baseball		Football		Hockey		Basketball		Golf	
		1	2	1	2	1	2	1	2	1	2
RI.1	Read closely to determine what science text says explicitly; make logical inferences; cite specific evidence to support conclusions drawn from text	●	●	●	●	●	●	●	●	●	●
RI.3	Analyze how a key idea is introduced, illustrated, and elaborated in a text through examples	●				●	●	●	●		
RI.4	Determine the meaning of technical words/phrases as they are used	●	●	●	●	●	●	●	●	●	●
RI.7	Interpret information presented in charts; explain how the information contributes to an understanding of the text	●		●			●	●	●	●	
RI.8	Evaluate specific claims, distinguishing claims that are supported by evidence from claims that are not					●		●		●	
SL.1	Engage in a range of collaborative discussion with diverse partners on topics, texts, and issues, building on others' ideas and expressing clearly	●				●		●			
	Review key ideas expressed and demonstrate understanding	●	●	●	●	●		●			●
SL.2	Interpret information presented in diverse media and formats	●	●	●	●	●	●	●	●	●	●

Reading for Science and Technical Subjects (RST): Gr 6-8		Baseball		Football		Hockey		Basketball		Golf	
		1	2	1	2	1	2	1	2	1	2
RST.1	Cite specific textual evidence to support analysis of science and technical texts	●	●	●	●	●	●	●	●	●	●
RST.3	Follow precisely a multi-step procedure when carrying out experiments		●	●	●						
RST.4	Determine the meaning of domain-specific words and phrases as used in a scientific or technical context	●	●	●	●	●	●	●	●	●	●
RST.7	Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a chart or table)	●	●	●	●	●	●	●	●	●	●

cont.

STANDARDS

Next Generation Science Standards: Gr 4-8		Baseball		Football		Hockey		Basketball		Golf	
		1	2	1	2	1	2	1	2	1	2
Physical Science (PS)											
PS.2A	Forces and Motion	●	●	●	●					●	●
PS.3A	Definitions of energy (kinetic/potential)							●			
PS.3B	Conservation of energy and energy transfer	●						●			
PS.3C	Relationship between energy and forces	●						●			
Crosscutting Concepts (CC)											
CC.2	Cause and Effect: Mechanism and explanation	●	●					●	●	●	●
CC.3	Scale, Proportion and Quantity							●			
CC.4	Energy and Matter	●	●	●	●			●	●		
CC.6	Structure and Function						●	●	●		
Science & Engineering Practices (SEP)											
SEP.3	Plan and carry out investigations		●	●	●		●				
SEP.4	Analyze and interpret data	●					●	●		●	
SEP.5	Use mathematics and computational thinking		●		●		●		●		●
SEP.9	Obtaining, evaluating and communicating information		●				●				

UNIT OF STUDY

INTRODUCING THE UNIT OF STUDY TO YOUR STUDENTS

Introduce your students to *Game On!* by drawing connections between science, technology, engineering and math and the sports included in this unit of study. This simple introductory activity focuses students by tapping into what they already know and understand about sports and STEM.

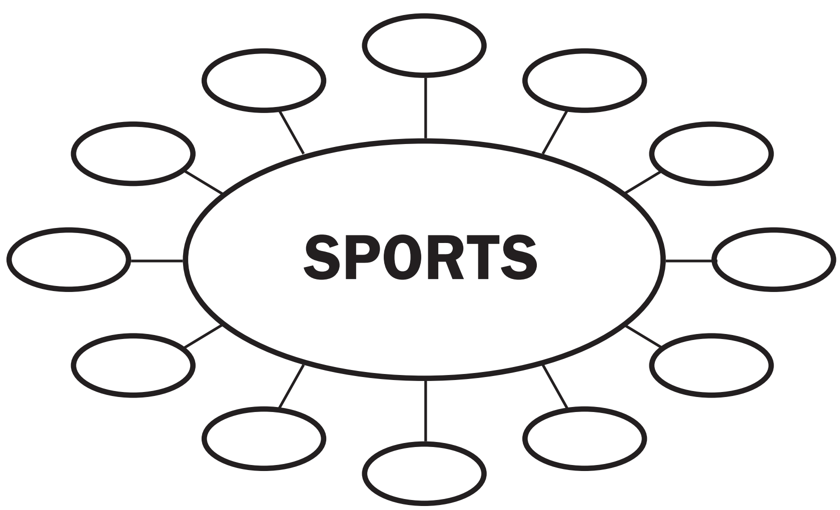
OBJECTIVES:

- Connect STEM to the five sports in this unit of study
- Understand the impact of STEM on gear and equipment over time
- Develop communication, collaboration and critical thinking skills

SAY: *Athletes in the 21st century compete in expansive arenas or on well-groomed fields with state-of-the-art gear and digital scoreboards to track scores and provide instant replay. But athletes thousands of years ago competed in venues vastly different with equipment that was not nearly as safe and not standardized. Ancient archers, discus throwers or swordsmen engaged in competition using equipment forged by hand.*

SAY: *As people observed the world around them, science and mathematics developed. Over time, people applied scientific and mathematical principles to create, or engineer, products including equipment used in sports. The application of science and math to create a product is called technology. Today science, technology, engineering and math are known as STEM – and STEM has a big impact on every sport that's played. In Game On! we are going to learn how STEM and sports work – and play – together.*

DRAW: This graphic organizer.



UNIT OF STUDY

SAY: *Let's begin by forming groups of 2 to 4 students to brainstorm. How many different kinds of sports can you name? Fill each circle in this diagram with a different sport. Then add to the circle the unique equipment or gear needed to play that sport.* (Answers will vary: archery, baseball, basketball, cycling, fencing, field hockey, fishing, football, golf, gymnastics, high jumping, ice hockey, lacrosse, running, cross-country skiing, downhill skiing, water skiing, swimming, water polo, etc.)

REVIEW and **DISCUSS** how science, technology, engineering and math influence equipment design. Everything from the shape of a football to the dimples on a golf ball connects to science and math.

SAY: *In this unit of study we will look more closely at how STEM is linked to five particular sports: baseball, football, ice hockey, basketball and golf.*

DISTRIBUTE the worksheet. **REVIEW** the directions, definitions and examples. Allow time to work in groups. Have students meet with other "sport alike" groups to share and exchange information.

SHARE: Have "sport alike" groups share with the class.

CLOSURE: *Now that you're warmed up, let's move into Game On! to learn more about STEM and sports.*

INTRODUCING GAME ON!

Names: ______________________________

1. With your teammates, circle one of the sports listed below.
2. Review the definitions of Science, Technology, Engineering and Math (STEM) in each box.
3. Brainstorm how Science, Technology, Engineering and Math are part of the sport you chose. (One example for football is shown in each box.)

Sport (circle one): Basketball Baseball Football Ice Hockey Golf

Science	Technology
Learning about and understanding the natural world through observation and experimentation	Applying what is learned through science.
Example: Figuring out why a football moves through the air differently when a quarterback changes his grip.	*Example: Writing the software program that runs the scoreboard.*
Engineering	**Math**
Applying scientific knowledge, mathematics and real experiences to design objects.	A branch of science that studies numbers, quantities, shapes, and how they are interrelated.
Example: Designing the electronic scoreboard that shows instant replays of a football game.	*Example: Tracking the number of passes completed compared to how many times a football is thrown.*

BASEBALL: LESSON 1

OBJECTIVES

Students will:

- Understand three forces that affect a baseball (drag, lift, gravity)
- Build content vocabulary
- Identify facts in expository text
- Complete "if … then" charts to compare pitches
- Use graphic organizers to record data

You will need:

- *Game On!* Page 4, "Baseball – the Physics of Pitching" – one per student
- Science Notebook – one per student (or electronic if online)

Vocabulary:

- physics – *n*. (Greek *physike* natural) science that deals with matter, energy, motion and force
- friction – *n*. (Latin *frictio* rubbing) rubbing one thing against another
- gravity – *n*. (Latin *gravitat* heaviness) a force that causes objects to fall toward the earth

WARM UP

SAY: *Imagine yourself at a baseball park. Think for a minute about all the things you might see moving in the game*. **RECORD** responses (e.g., balls flying, bats swinging, players running, outfielders diving, catchers throwing, runners sliding). *Physics is a branch of science that studies matter, energy and how things move. In today's lesson we'll learn how different forces work on a baseball, and how physics helps strike out batters!*

SCAFFOLD: Create the following chart on the board. Have students copy the chart in their Science Notebooks and take notes as part of "close reading."

SAY: *As you read the page 4, find three forces that affect a baseball. Describe how each force acts on an object*. (Answers shown)

REVIEW responses.

What is "drag"?	What is "lift"?	What is "gravity"?
a force that slows a moving object	an upward motion created by the force of an object moving through air	a force that pulls an object downward

SAY: *As you read "Force and Energy" look for words that fit these sentences*.

- A ball needs energy so it can overcome _______ (A: gravity).
- The pitcher's wind up puts a force on the ball to give it _______ (A: energy).

SAY: *Cup your hand and move it quickly back and forth. Can you feel the air? This is the same feeling you get on your face when you run or ride a bike. What you're feeling is actually the friction of the air as your face or hand moves through it.*

Friction makes a difference to a pitcher! As soon as the pitcher releases the ball, air starts slowing it down. The friction of the air causes a force that is opposite to the forward-moving force that the pitcher puts on the ball. This opposite force is called "drag." Pitchers "wind up" a particular way to put greater force on the ball.

ACTION: Direct students to stand up and pantomime winding up and throwing an imaginary baseball as hard as they can. *How far do you think your ball will travel?* Then pantomime throwing a ball gently. *How far will this ball go?*

DISCUSS: *What happens when a small force is put on a ball when thrown?*

BASEBALL: LESSON 1

GAME TIME

SAY: *There are a dozen different ways a pitcher can throw a baseball to try striking out a batter. Pitches have different names—from fastball to cutter, slider, splitter—even a "screwball!" One popular pitch is a curve ball. As you read page 5,* ("Does a curve ball actually curve?") *record at least five facts in your Science Notebook about the curve ball.* (Additional answers shown)

Facts About Curve Balls
1. can curve up to 18"
2. hard to hit
3. as ball spins, top surface moves in same direction as air
4. bottom air and ball move in opposite directions
5. spinning ball throws air down
6. air pushes ball up
7. backspin creates lift

DIFFERENT STROKES: SCAFFOLD: Help students compare pitches with a graphic organizer. Write "if" statements in the first column. Help students complete the "then" column.

If …	… then
If you throw a curve ball …	*… the ball will drop downward towards the dirt*
If you throw a slider …	*… the ball will drop downward and to the left*
If you throw a screwball …	*… the ball will drop downward and to the right*

POST-GAME HIGHLIGHTS

1. **Critical Thinking:** *How might a taller pitcher have an advantage over a shorter pitcher?* (A: releases ball closer to the plate, longer arms for greater velocity, more downward spin on ball, etc.)

2. **Beyond Baseball:** Use the Internet to research, illustrate and explain different kinds of pitches.

3. **Imagin-eer:** In your Science Notebook illustrate drag, lift and gravity. Then draw a curve ball, slider and screwball and show how these three forces work on each pitch.

BASEBALL: LESSON 2

OBJECTIVES

Students will:

- Understand forces that affect a throw (force, forward motion, gravity)
- Calculate "Batting Average" and "Earned Run Average" (ERA)
- Build content vocabulary
- Conduct a simple experiment
- Use "if/then" and "cause/effect" statements

You will need:

- *Game On!* Page 6, "Baseball – Angled for Distance" – one per student
- Science Notebook – one per student (or electronic if online)
- Calculators
- Baseball bats, hammers, sticker or tape

Vocabulary:

- angle – *n*. (Latin *angulus* corner) a figure formed by two rays sharing a common end point
- average – *n*. (Arabic *awariyah* damaged merchandise) a quantity that represents the mean
- vibration – *n*. (Latin *vibratus* move to and fro) the periodic motion of an object

WARM UP

ASK: *The pitcher isn't the only player that uses math and physics in a ballgame. All nine players use math to catch, field, throw accurately and go the distance to help their team.*

DO: Write the following guiding questions on the board.

SAY: *As you read "closely" today, find and underline evidence to answer these guiding questions.*

Guiding Questions	Answers
How far does a center fielder have to throw the ball?	*more than 200 feet*
What does the force of the throw do to the ball?	*gives the ball a forward motion (makes it go forward)*
What force acts on a moving ball to pull it downward?	*gravity*
How should a fielder throw the baseball to get the greatest distance before gravity pulls it down?	*upward and outward at the right angle*
What is the best angle for a fielder to throw the ball?	*45 degrees*

DISCUSS: *What happens if a player throws the ball straight up or at too high of an angle? What if a player throws too low to the ground or too small of an angle?*

GAME TIME

SAY: *Coaches, players, team owners and fans use math to keep records on how well players perform. Facts include how many times a player hits the ball, gets to base, makes an error or scores a run.*

DO: Allow time for students to add more statistics they may know.

SAY: *Two very important statistics in baseball are the "batting average" of each player and the "earned run average" of pitchers.*

DIRECT the students to locate and read page 6, "Let's Talk Stats." **REVIEW** formulas one at a time. **DISTRIBUTE** calculators. **ASK** students to calculate the following batting averages and earned run averages. Then rank players for batting averages and ERAs from best to next best, etc.

NOTE: A higher batting average is better; a lower ERA is better.

BASEBALL: LESSON 2

Batting Average

Player	# of Hits	# of Times at Bat	Batting Average	Ranking
Pat Pitcher	1	10	*1/10 = .100*	4
Chris Catcher	4	12	*4/12 = 1/3 = .333*	2
Frankie First Base	6	10	*6/10 = .600*	1
Olive Outfield	5	20	*5/20 = ¼ = .250*	3
Sam Shortstop	2	20	*1/20 = .050*	5

Earned Run Average

Pitcher	# of Runs	# Total Innings	Earned Run Average (Runs x 9)/Innings	Ranking
Diego	12	68	*12 x 9 = 108/68 = 1.58*	4
Diana	6	42	*6 x 9 = 54/42 = 1.29*	3
Don	20	100	*20 x 9 = 180/100 = 1.80*	5
David	8	58	*8 x 9 = 72/58 = 1.24*	2
Dana	4	63	*4 x 9 = 36/63 = 0.57*	1

Scientist's Notebook – Finding the "Sweet Spot"
SAY: *Batters try to hit the ball on the "sweet spot" to make the ball travel farther and faster.*

DIRECT students to read the experiment and underline key words before distributing materials to small groups. Next, answer the following "If … then … so" statements comparing the "sweet spot" to any other place on the bat. Finally, complete the "cause" and "effect" chart.

If …	… then …	… so
If you hit the bat with the hammer …	*… the bat moves sideways and bends …*	*… you feel vibrations.*
If you hit the sweet spot …	*… the bat doesn't bend as much …*	*… you feel no vibrations.*

Cause	Effect
Because energy isn't going into vibrations …	*… more energy goes to the ball, and the ball goes faster and farther!*

BASEBALL: LESSON 2

POST-GAME HIGHLIGHTS

1. **Be the Coach:** Imagine you're the coach and a player wants to know how to improve his throwing, pitching or batting. Based on what you learned in this section, what advice might you give?

2. **Beyond Baseball:** Use the Internet to research the batting averages and ERA's of players on your favorite team.

3. **Imagin-eer:** In your Science Notebook illustrate three different angles for a center fielder to throw the ball. Explain in writing what will happen with different angles.

FOOTBALL: LESSON 1

OBJECTIVES

Students will:

- Understand Newton's First and Second Laws of Motion in the context of football
- Build content vocabulary
- Locate text-dependent information
- Construct "if ... then" statements and paraphrase the gist
- Use graphic organizers to record data

You will need:

- *Game On!* Page 8, "Aerodynamics in Football" – one per student
- Science Notebook – one per student (or electronic if online)
- A football and a wad of tissue paper

WARM UP

ASK: *What do people mean when they say they are "forced" to do something?* (Record responses)

SAY: *In physics, a "force" is when power is exerted upon an object. This force, or action, makes an object move as a "reaction." What kinds of "forces" (or actions) do you see in a typical game of football?*

SCAFFOLD: Create the following chart on the board with five guiding questions in the first column. Have students copy the chart in their Science Notebooks, and ask students to select three guiding questions that most interest them to answer as they read.

SAY: *As you read "Aerodynamics in Football," look for answers to three of the questions that most interest you.*

Guiding Questions	Answers (Sample responses shown)
1. What does the unique shape of a football let players do?	*The shape lets players put "spin" on the ball when thrown or kicked.*
2. How does "spin" on a football affect its motion?	*Spin creates airflow over the ball.*
3. Why do "spin" and airflow matter in football?	*Spin and airflow matter because gravity is working to pull the ball down.*
4. What affect does the quarterback's grip have?	*Different grips get more lift.*
5. How does air flow work on a football?	*Air traveling above the ball is forced downward by the spin, and the air below creates lift.*

REVIEW the unique shape of a prolate spheroid and responses using a football.

GAME TIME

TACKLING NEWTON'S LAWS

SAY: *Football players may not realize they are using the principles of physics during a game. A scientist named Sir Isaac Newton developed three laws about moving objects called "Newton's Three Laws of Motion." Read the section about Newton's First and Second Laws of Motion and see if you can locate the missing information in these "If … then" statements. Then rephrase his words using a football example.*

FOOTBALL: LESSON 1

OBJECTIVES

Vocabulary:

- force – *n*. (Latin *fortis* strong) power exerted upon an object
- prolate – *adj*. (Latin *prolatus* bring forward; extend) elongated or lengthened along the diameter
- spheroid – *n*. (Greek *sphairoeidḗs*) a solid geometric figure in the shape of a sphere (like a ball)
- gyroscope – *n*. (Greek *gŷros* ring and *skopion* to look at) a device consisting of a heavy disk or wheel spun rapidly about an axis like a top
- axis – *n*. (Latin *axis* a wild animal of India) a central line that bisects a figure
- inertia – *n*. (Latin *inertia* unskillfulness, idleness) the property of matter by which it retains a state of rest or its velocity in a straight line so long as it is not acted upon by an external force

If …	… then	In other words …
First Law: • If an object is set in motion …	• … then it doesn't change its motion unless another force acts upon it.	• If you throw a football, it will keep moving until gravity pulls it down. Without gravity, it would keep traveling!
• If an object has more mass …	• … then it will take more force to change its motion.	• If a big player is carrying the ball, it will take another big player to stop him.
Second Law: • If force is applied to an object (or mass) …	• … then it will begin to move.	• If you use force to throw or kick a football, it will travel. Otherwise, the football will sit on the ground!

REVIEW: The definition of "inertia." Discuss how a football thrown on the moon travels much farther than on earth because there is much less gravity. At zero gravity, a football would keep moving through space unless something crashed into it to slow it down, stop it or change its direction.

DEMONSTRATE Newton's First and Second Laws of Motion using a football and a wad of tissue paper. Show students that it takes more force to stop a moving football than a moving wad of tissue paper because the football has more mass.

POST-GAME HIGHLIGHTS

1. **Mass Demonstration:** Throw objects of different mass like a football, baseball, wad of newspaper, wad of tissue paper, cotton ball and compare how much force it takes to make them move or stop moving. Compare distance of objects of different mass thrown with the same force. Record findings in your Science Notebook.

2. **Picture This:** Illustrate spin, mass, force, and Newton's First and Second Laws of Motion in your Science Notebook.

FOOTBALL: LESSON 2

OBJECTIVES

Students will:

- Understand Newton's Third Law of Motion in the context of football
- Build content vocabulary
- Connect geometry and Pythagorean Theorem to football "X's" and "O's"
- Construct "if ... then" statements
- Evaluate safety features enhanced through technology over time

You will need:

- *Game On!* Page 10, "Newton's Third Law of Motion" – one per student
- Science Notebook – one per student (or electronic if online)
- Book, pencil, wad of paper or other objects to push

WARM UP

ASK: *What do you remember about Newton's First and Second Laws of Motion?* (Record responses)

SAY: *Remember that in physics, a "force" is a power exerted upon an object. This force, or action, makes an object move as a "reaction." Newton's Third Law of Motion has to do with action and reaction.*

SCAFFOLD: Continue the "If ... then" chart from Lesson 1.

SAY: *As you read "Newton's Third Law of Motion," locate the information in this "if ... then" statement. Finally, rephrase his words using a football example.*

If….	…then	In other words…
Third Law: • If there is an action ...	• ... there is an equal and opposite reaction (forces act in pairs)	• Player "A" (running with the ball) is tackled by Player "B." Player "A" falls to the ground.

DEMONSTRATE: Have students experiment. Gently push a book, wad of paper, a pencil or other objects. Observe the action (pushing) and reaction (object moving). Now apply more force to the same objects and observe that more force (pushing harder) results in a greater reaction (more distance moved).

GAME TIME

TACKLING MATH

SAY: *Geometry is the branch of mathematics that deals with the properties of shapes or figures. Squares, circles, rectangular prisms and prolate spheroids (a football shape) are figures that mathematicians measure and study by using the principles of geometry. As you read "Tackling Math" on page 10, you will learn a little about the geometry of football.*

DEMONSTRATE: Draw an "X" and an "O" on the board to illustrate two football players. "O" is an offensive player—or team with the ball—and "X" is a defensive player—or team trying to stop "O" from scoring. Connect the "X" and the "O" with a line. Draw a second line from the right of the "O" about six inches long and make a dot. Draw a line from the "X" to the same dot to complete a triangle.

SAY: *You can see that "X" tries to avoid getting tackled by "O" by moving at an angle. "O" has to move in that direction to stop him. Their movements create a triangle. What happens if the "O" moves at a different angle?*

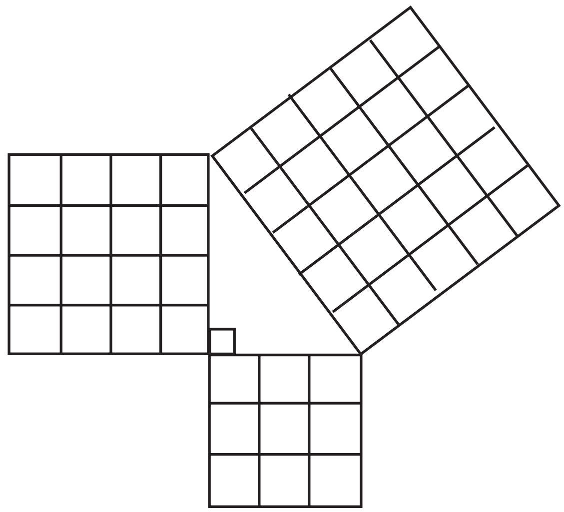
FOOTBALL: LESSON 2

OBJECTIVES

Vocabulary:

- geometry – *n*. (Greek *geōmetría* measure the earth) the branch of math that deals with properties of figures
- Pythagoras – *n*. Greek philosopher and mathematician (c.582-500 BC) who theorized that numbers are the essence of all things. He developed the Pythagorean Theorem.
- theorem – *n*. (Greek *theṓrēma* a thesis to be proved) in mathematics, a proposition, formula or statement about something to be proved using other formulas.
- evolution – *n*. (Latin *ēvolūtiōn* an unrolling) the process of development or growth

DEMONSTRATE the Pythagorean Theorem using the following illustration. Explain that the "square" of the hypotenuse (in this case 5 x 5 = 25) is equal to the sum (total) of the squares of the other two sides (3 x 3 = 9 and 4 x 4 = 16). So 9 + 16 = 25 square units.



POST-GAME HIGHLIGHTS

1. **Be the Coach:** Ask students to illustrate in their Science Notebooks play options using "X's" and "O's" that show four or more different triangles created by offensive and defensive moves.

2. **Geometric Challenge:** Illustrate the Pythagorean Theorem in your Science Notebook with a right angle triangle that measures 9 units on one side, 12 units on the second side and 15 units on the hypotenuse.

3. **Who was this guy?** Use the Internet to learn more about Pythagoras and his other contributions to math. Can you locate information about other famous mathematicians in history? What were their contributions? Make a poster illustrating Math Genius!

HOCKEY: LESSON 1

OBJECTIVES

Students will:

- Understand how engineering and technology make hockey a safer sport
- Build content vocabulary
- Sequence information
- Determine accuracy of text-dependent claims
- Find evidence through close reading
- Use graphic organizers to record data

You will need:

- *Game On!* Page 12, "The Chemistry of Hockey" – one per student
- Science Notebook – one per student (or electronic if online)

WARM UP

SCAFFOLD: Create the following "Know" and "Need to Know" chart on the board.

SAY: I*ce hockey is a fast contact sport played on ice between two teams. Before reading, let's find out how much you already "know" about hockey and what you might "need to know."* (Chart responses.)

Know	Need to Know

REVIEW responses.

SAY: *How might a game like hockey be dangerous?* (List)

GAME TIME

SAY: *One of the critical components of ice hockey is a safe skating surface. Uneven or broken ice can cause a player to fall and get hurt. Scientists use chemistry to make the ice as safe as possible. Chemistry also makes hockey more exciting so that the players and pucks will move smoothly and quickly – but not so fast that players lose control.*

GUIDING QUESTION: *What different layers are needed to make a smooth and safe skating surface?*

Layer	Description (Answers Shown)
First	a 1/32" clear base
Next	a 1/32" layer painted white
Then	a 1/16" clear layer
Next	a layer for painting lines and team logos
Finally	10 layers one on top of the other to make ice 1" thick

SAY: *As you read closely, underline evidence to support the following claims.*

Claim	Evidence (Answers Shown)
1. Ice hockey is rigorous sport for athletes.	"During one game, players will skate nearly 200 miles."
2. Building the surface in thin layers is safer.	"… building layers creates a stronger surface that won't crack."
3. Scientists have developed the ideal skating surfaces for ice hockey.	"Chemistry studies help pros find just the right amount of minerals for a perfect ice surface."

HOCKEY: LESSON 1

OBJECTIVES

Vocabulary:

- engineer – *n*. (Latin *ingenia* design; devise) a person skilled in design, construction and use of machines or engines
- technician – *n*. (Greek *technikos* art and craft) a person skilled in mechanical or industrial techniques
- chemistry – *n*. (Greek *chemia* alchemy) science that deals with properties and forms of matter
- rink – *n*. (Scots *renk* battle) a smooth sheet of ice for skating often in an arena

BATH MATH
ASK: *If it costs $2.00 to fill one 50-gallon bath tub with water, how much would it cost to cover an ice rink 1 inch thick?* (A: $424.00)

MAKING RINK ICE
DIRECT the students to sequence the following information. Identify Step #1.

Steps (Answers shown)	Making Ice
1 (provide)	Lay down pipes
3	Fill pipes will chilled salt water
5	Freeze purified water
4	Spray purified water on concrete slab
2	Build a concrete slab on top of pipes

THE STORY OF THE HOCKEY PUCK – Page 13
SCAFFOLD: Write the following process for "close reading" on the board.
1. Pronounce all missing words with teacher; repeat.
2. Read the entire selection first to "get the gist."
3. Re-read the entire selection and underline clues in each sentence that have a missing word.
4. Select a word from word bank that makes the most sense.
5. Re-read the sentence with your word. Does it sound right and make sense?

PROVE IT!
SAY: Locate proof in the text to support these claims.

Claim	Proof
Rubber was invented more than 150 years ago.	rubber invented in 1839
Hockey pucks have been made out of many different materials.	balls, stones, lumps of coal, etc.
Ice hockey skates are different from regular ice skates.	groove in the center of blade; two sharp edges

POST-GAME HIGHLIGHTS

1. **Imagin-eer:** You're the coach of a new team. Select a mascot and design a logo.
2. **Think Twice:** Summarize how science is part of hockey. Consider ice surface, hockey puck, ice skates or composition of water.
3. **Explore:** Use the Internet to score answers! *How old is hockey? Where did it begin? How many teams are in professional hockey today? What is the name of the professional team closest to your town or city?*

HOCKEY: LESSON 2

OBJECTIVES

Students will:

- Understand that engineers invent machines
- Build content vocabulary
- Sequence information
- Conduct a simple experiment with multiple trials
- Understand the importance of protective gear

You will need:

- *Game On!* Page 14, "Technology on the Ice" – one per student
- Science Notebook – one per student (or electronic if online)
- Yardstick (one per team)

Vocabulary:

- filter – *n*. (Latin *filtrum* felt used to strain) a substance through which liquids pass to catch impurities
- surface – *n*. (Latin *superficies* on the face) the utmost layer
- observation – *n*. (Latin *observar* to watch) act of viewing or noting a fact for science
- reaction – *n*. (Latin *re+actum* something done again) action of a muscle in response to stimulus

WARM UP

SAY: *With players skating over 200 miles during one game, the ice takes quite a beating. It's critical for the safety of the players to keep the ice as smooth as possible. This means stopping the game to clean and smooth the ice. Imagine you've been asked to invent a machine to do this job. What features might such a machine need?* (Allow time for brainstorming. Chart ideas.)

SAY: *60 years ago an American inventor named Frank Zamboni owned an ice skating rink in Los Angeles. He figured out a solution for smoothing ice that saved lots of time during a game. As you read, look for the answer to this GUIDING QUESTION: What are at least three things that Frank Zamponi's invention can do?* (A: shave the ice, collect the ice, wash/rinse the ice shavings and resurface the ice)

ASK: *How does the Zamponi compare with the features you imagined your machine might need?*

Features of Our Invention	Features of a Zamponi
List student ideas	• Built on wheels like a truck • Blade to cut or shave the ice • Snow tank for "ice making" • Water to rinse the shavings • Filter to clean the shavings • Water spreading device • Heavy towel to spread water on surface

SAY: *Technology is the use of science to find solutions or invent useful devices. Engineers are people who study how to design, build, test and operate machines that can improve our lives. Frank Zamboni used engineering concepts and technology to invent his ice-shaving machine that was both useful and solved a problem!*

HOCKEY: LESSON 2

GAME TIME

THE REACTION TIME TEST

SAY: *One very important player on a hockey team is the "goalie." His job is to prevent the opposing team from scoring a point by stopping the hockey puck from entering the net. With a puck traveling so fast, what kind of safety equipment might a goalie need for protection?* (List ideas)

SAY: *In addition to protective gear, goalies must be equipped with quick reflexes. It takes many years of practice to move that quickly. Today's experiment will test your reflexes to see if practice makes a difference in your response time.*

DO:

1. Review steps and illustrations on Page 15, The Reaction Time Test. Point out how text features (e.g., illustrations, layout) help comprehension.
2. Model activity
3. Check for understanding
4. Form teams
5. Distribute yardsticks
6. Allow adequate time for 10 trials per teammate

ASK: Did your reaction time improve with each trial? How much?

SCIENCE SCOOP

SCAFFOLD: Record information in a comparison matrix.

	Catching (in inches)	Reaction Time
Most people	6" to 8"	.177 to .204 seconds
Professional goalie	4.5"	.100 seconds

POST-GAME HIGHLIGHTS

1. **Imagin-eer:** Draw a picture in your Science Notebook of your ice-shaving invention. Label features.

2. **Ice Hockey Trivia:** Use the Internet to research ice hockey. Create a class trivia game from the facts discovered. Sample questions:
   - How many players on a team?
   - What are names of positions on a team?
   - How is ice hockey scored?
   - How long is a game? (minutes of playing time)
   - What are names and mascots of different teams?
   - How long and wide is the rink?

BASKETBALL: LESSON 1

OBJECTIVES

Students will:

- Understand three kinds of energy (potential, kinetic, thermal)
- Build content vocabulary
- Determine accuracy of text-dependent claims
- Think critically about physical forces
- Use graphic organizers to record data

You will need:

- *Game On!* Page 16, "Bounce: It's About Energy" – one per student
- Science Notebook – one per student (or electronic if online)

Vocabulary:

- kinetic – *adj*. (Greek *kinetikos* moving) caused by motion
- potential – *adj*. (Latin *potent* to have power) possible as opposed to actual
- thermal – *adj*. (Greek *thermos* hot) caused by heat or temperature
- energy – *n*. (Greek *energeia* activity) capacity for vigorous activity; available power

WARM UP

ASK: *What do people mean when they say they have a "lot of energy"?* (Chart responses.) *Energy gives people—and things—the power to move. Today we're going to learn about energy and the science of basketball. Athletes, and the basketballs they use, both use energy to score points.*

SCAFFOLD: Create the chart below with two prompts in the first column and headers in the next three columns. Have students copy the chart in their Science Notebooks and take notes in the six boxes for "close reading."

SAY: *As you read the first section, look for three kinds of energy and note how each is different from the other. Find an example for each kind of energy using a bouncing basketball.* (Answers shown.)

	Kinetic	Potential	Thermal
Definition?	Energy of motion	Energy based on position (stored)	Energy from temperature of matter
Basketball example?	A basketball moving or bouncing	A basketball held above the ground	A basketball hitting the ground slows from friction and heating slightly

REVIEW responses.

GAME TIME

SAY: *Now that you know about three kinds of energy in basketball, underline evidence to decide if the following claims are TRUE or FALSE.* (Answers shown.)

Claims	True	False
a. As a ball falls it begins to lose kinetic energy.		x
b. When it hits the ground, the ball has lots of kinetic – or motion – energy.	x	
c. Potential energy in a basketball turns into both thermal and kinetic energy.	x	
d. If you drop a basketball and let it bounce, the bounce gets higher and longer.		x

BASKETBALL: LESSON 1

THE BOUNCE FACTOR
SAY: Think about different kinds of balls used in different sports. How many different kinds can you list? Why do different sports need different kinds of balls?

SAY: As you read this section, use this chart to note facts about how height, surface and temperature affect the bounce of a ball. (Potential answers shown.)

Height	Surface	Temperature
• Higher ball has more potential energy. • As ball drops, it gains speed. • Potential energy converts into kinetic energy. • The longer the fall, the more kinetic energy and the higher the bounce.	• Springier surfaces change more as ball hits them. • Molecules do not have to do as much flattening. • Softer surfaces like trampoline & ball bounces higher and faster.	• Ball gets warmer as it bounces. • Balls bounce higher and faster when warmer.

Fill in the Blank – Cause and Effect
1. Because a basketball gains speed as it is dropped, the potential energy is changed into ___________. (A: kinetic energy)
2. Because springier surfaces act like a trampoline, a ball bounces ____________ when it hits. (A: higher and faster)
3. Because air molecules inside a basketball expand when it is warmer, the ball will _____________. (A: bounce higher and faster)

POST-GAME HIGHLIGHTS
1. **Chat it UP!** Working with a partner, explain the difference between kinetic, potential and thermal energy.

2. **Imagin-eer!** Create a three-panel comic strip about a talking basketball that explains how energy changes when it is bounced.

BASKETBALL: LESSON 2

OBJECTIVES

Students will:

- Understand the connection between parabolic arcs and basketball
- Build content vocabulary
- Use guiding questions for close reading
- Locate text-dependent information
- Use graphic organizers to record data

You will need:

- *Game On!* Page 18, "Pondering the Parabolic Arc" – one per student
- Science Notebook – one per student (or electronic if online)
- Basketball
- Protractors

Vocabulary:

- parabola – *n*. (Greek *parabole* throwing) a special curve shaped like an arch
- diameter – *n*. (Greek *diametros* measure diagonal) a straight line passing through the center of a circle
- structure – *n*. (Latin *struere* to put together) something built or constructed

WARM UP

DRAW a curved line on the board. **ASK:** *What is the name of this figure?* (Record responses.)

SAY: *A technical name for this curved line is a parabola or parabolic arc. Without parabolic arcs, it would be impossible to play basketball. Today we'll learn more about why athletes practice shots that follow a parabolic arc to score.*

SCAFFOLD: Create the following chart on the board with two guiding questions in the first column. Have students copy the chart in their Science Notebooks.

SAY: *As you read page 18, "Pondering the Parabolic Arc" look for answers to these guiding questions.*

Guiding Question	Answers (Sample responses shown)
What happens if the ball hits the rim of the hoop?	It has a greater change of bouncing out.
Why does a player throw the ball in an arc?	The ball goes over and high above the rim to enter from above. This increases the chances of scoring!

REVIEW responses.

GAME TIME

SAY: *A parabolic arc makes all the difference in making a basket. But there's even more geometry involved with making shots! Read page 18, "Swish the Geometry" and see if you can locate the missing information in these "If … then" statements.*

If …	… then
a. If the hoop is 18" in diameter, and the basketball about 9.4 inches wide,	… then the hoop is about ______ inches wider than the basketball. *(A: estimate 9", actual 8.6")*
b. If a ball is dunked at a 90° angle straight into the hoop,	… then the ball is likely to__________. *(A: sink all the way through to score)*
c. If a ball is shot from further away,	… then the ball needs to be __________. *(A: shot at an angle)*
d. If a player increases the entry angle of the ball's arc,	… then the ball has _________ and a greater chance ____________. *(A: more space; to score)*

BASKETBALL: LESSON 2

THE BIG DROP
ASK: *How can we calculate how high a ball will bounce? Scientists solve problems, check estimates and formulate theories by using math.*

DEMONSTRATE the relationship between height and bounce by using a basketball. Next show how the bounce was calculated at 80% when dropped from the Statue of Liberty.

DIRECT students in teams of two to solve the remaining calculations; one partner solves in feet, while the other solves in meters.

POST-GAME HIGHLIGHTS

1. **Angle Tangle!** Use a protractor to illustrate angles of 30°, 45°, 55° and 90° in your Science Notebook. Explain to a partner how the angle makes a difference in successful shooting.

2. **The Shot Clock's Ticking!** Basketball is a fast sport, and professional players have only 24 seconds to take a shot! How many of these 3-point math problems can you complete in 24 seconds?

8 x 3	3 x 7	5 x 3	17 - 3	8 + 3	12/3	11 - 3	3 + 9
18/3	21 - 3	3 x 3	15/3	3 x 0	15 - 3	6/3	9 x 3

1 – 3 baskets = Jump shot!
4 – 5 baskets = Free throw!
6 – 7 baskets = Slam dunk!
8+ baskets = All Star!

GOLF: LESSON 1

OBJECTIVES

Students will:

- Understand how gravity and angle affect the distance of a golf ball
- Build content vocabulary
- Determine accuracy of text-dependent claims
- Use close reading to complete a "cloze" reading
- Interpret data shared in a table

You will need:

- *Game On!* "Breaking on the Green" – one per student
- Science Notebook – one per student (or electronic if online)
- Protractor (1 per student or team of two)

WARM UP

SCAFFOLD: Create the following "Know" and "Need to Know" chart on the board.

SAY: *Golf is a sport that has been around for many centuries. Like all sports, it requires skill and strategies to overcome challenges and win the game. Let's begin by finding out how much you already know about golf, and what you might want to learn as we begin swinging!* (Chart responses)

Know	Need To Know

REVIEW responses.

BREAKING ON THE GREEN

SAY: *Golf courses look smooth and green but are built with slopes that can make a ball travel in unwanted directions. This is part of the fun and frustration of golf.*

SAY: *As you read closely, underline evidence to support the following claims.*

CLAIM	EVIDENCE (Answers shown)
Slopes make it difficult to control the ball on a course.	*"… Although golf courses may appear flat, most have hills and dips that prevent a ball from traveling in a straight line."*
Golfers combine thinking and skills to get the ball into the hole.	*"… The golfer must make the ball curve, or break, toward the hole."* *"A golfer hits the ball slightly uphill to use the tilt of the ground to make the shot."*

HOW MUCH SPIN?

DIRECT students to the angled club faces.

SAY: *Look for the answers to these questions as you read.*

1. *What controls the speed and direction of a shot?* (A: Spin)
2. *What angles are better for long shots?* (A: a slight angle or nearly vertical face)
3. *What angles are better for higher, shorter shots?* (A: a more angled face)
4. *What conclusion can you make about the relationship between distance and angle?* (A: the greater the angle, the shorter the distance traveled)

DISTRIBUTE protractors and have students measure the angles of the club faces in the illustration on Page 22. Record answers in Science Note book.

GOLF: LESSON 1

OBJECTIVES

Vocabulary:

- golf – *n*. (Old English *gowfe* club) a game in which clubs with heads of wood or metal are used to hit a small ball on a course with 9 or 18 holes
- resistance – *n*. (Latin *resistere* to remain standing) opposition of one force on another
- friction – *n*. (Latin *frictio* rubbing) surface relative resistance to motion; the rubbing of the surface of one object on another
- distance – *n*. (Latin *distant* to stand apart) the amount of space between two points

DIRECT students to the ANGLE and SPIN data table. **READ** the question.

ASK: *What does the information in this table tell us?* (A: The relationship between the angle on the face of a club and the number of spins or revolutions per minute)

SAY: *Data tells a story. Look at the data in this table and create a "fact" statement.*
Examples:

- The greater the angle, the greater the spin speed.
- A 30° angle has about four times the spin of a 10° angle.
- Between 50° and 60° there is not as much spin increase as between other angles.

SCAFFOLD: Write the following process for "cloze reading" on the board.

1. Read all words in the box with the teacher; clarify the meaning of any unfamiliar words.
2. Read the entire selection two times to "get the gist" – do not fill in words yet.
3. Read again and fill in the easy answers that you are sure are correct. Cross off words in the box as you use them.
4. Next, fill in the slightly more difficult words that sound correct. Cross off words in the box.
5. Finally, complete filling in the remaining words.
6. Re-read the sentences. Do the words make sense? Does the entire reading make sense?
7. Compare answers with a partner.

POST-GAME HIGHLIGHTS

1. **Imagin-eer"** Draw a Venn diagram comparing golf to baseball, football, hockey or basketball. How are they alike? How are they different?

2. **Think Twice"** Summarize in your Notebook how science is part of golf. Consider slopes on a golf course, angle of a club face, distance, spin or surface of golf balls.

3. **Explore"** Use the Internet to score answers! Who were the first Scots to play golf? What is the Grand Slam of golf? Who are the major players today?

GOLF: LESSON 2

OBJECTIVES

Students will:

- Understand that engineers make changes in equipment
- Build content vocabulary
- Draw to scale using centimeters
- Understand and calculate volume
- Conduct a simple experiment

You will need:

- *Game On!* "History of Golf Clubs" – one per student
- Centimeter ruler
- Graduated mL cylinder, water and marble small enough to fit in the cylinder
- Science Notebook – one per student (or electronic if online)

WARM UP

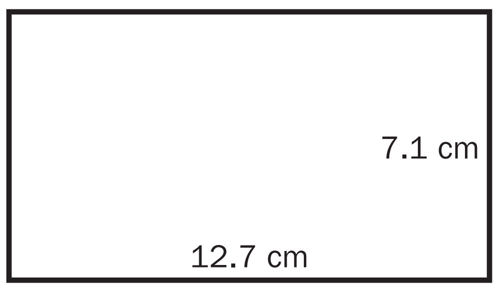
SAY: *Sports equipment changes often as new designs are engineered to get better results. It's no different with golf! Brainstorm with a partner the kinds of equipment and gear that are needed for a round of golf.* (e.g., clubs, bags, tees, balls, cleats, shoes, clothing, golf carts, bag carts, etc.)

SAY: *Originally, golf clubs were handmade. As you read this section, look for answers to these questions:*

1. Why were the original golf clubs called "woods"? (A: They were carved from wood.)
2. What did golfers discover when they hit with a hollow steel club? (A: They had more control over the ball.)
3. Why is titanium used today? (A: It is stronger and lighter than steel.)

SAY: *Golf clubs are often re-designed to use better materials, shapes and grips. There are strict rules, however, for the exact measurement of the golf club head.*

DRAW the shape and dimensions below on the board.



SAY: *Using your centimeter ruler draw a rectangle in your Science Notebook that is exactly 12.7 cm wide and 7.1 cm high. This is the precise size of the golf club head.*

CALCULATING VOLUME – Archimedes' Principle

SAY: *Figuring out the amount of space – or volume – of a golf club head can be tricky. Thanks to the ancient Greek mathematician and scientist, Archimedes of Syracuse, there is an easy way to check for volume. History tells us Archimedes was given a problem by King Hiero II who asked him to figure out if a golden crown was pure gold or if a dishonest blacksmith had replaced some of the gold with silver. Archimedes could not melt the crown or change its shape. One day when Archimedes was stepping into a tub of water, he noticed the water level rose as he got in. He determined that this method of "submersion" could be used to test the volume of the crown by comparing the mass of the golden crown to the volume of the water "displaced" and then to gold. Through his experiment, wise Archimedes was able to prove to King Hiero that the King had indeed been cheated by the blacksmith!*

GOLF: LESSON 2

OBJECTIVES

Vocabulary:

- distribute – *v.* (Latin *distributus* to divide) to spread over a space or area
- displacement – *n.* (Middle French *des+placer* remove) the weight or the volume of fluid that is “displaced” (takes the place of) by a floating or submerged body
- volume – *n.* (Latin *volumen* roll of sheets) the amount of space that an object occupies
- Archimedes’ Principle – the law that a body immersed in a fluid is buoyed up by a force (buoyant force) equal to the weight of the fluid displaced by the body

DEMONSTRATE:

1. Add an amount of water to a graduated cylinder and note the level in mL of the water.
2. Drop a marble in the water.
3. Note the new level in mL of the water.
4. Subtract the lower number from the higher number to determine volume.

NOTE: If you have enough cylinders and marbles for teams of 2 to 4, allow students to conduct their own experiment with different levels of water and the same size marble. Is the volume always the same no matter how much water is used?

DIRECT the students to record results in their Science Notebooks. Then ask students to read and complete the “Find an Object’s Volume” on Page 23.

POST-GAME HIGHLIGHTS

1. **Imagin-eer:** Draw a picture in your Science Notebook of the next generation golf club. What features might you engineer to improve the game? Label the parts – shaft, club, face, grip.

2. **Golf Trivia:** Use the Internet to research golf with a partner. Can you answer all questions in 15 minutes or less?
   - What is par on most golf courses? (72)
   - What are the four major championships in golf? (U.S. Open, British Open, The Masters and the P.G.A. Championship)
   - What is the maximum number of clubs allowed in the golf bag? (14)
   - Who won the British Open in 2015? (Zach Johnson)
   - In what city and state is the U.S. Masters played? (Augusta, Georgia)
   - What color is the jacket that the Masters champion gets to wear? (green)
   - Who owns the most major tournament titles? (Jack Nicklaus)