

THE SPORTS CHALLENGE

Teacher's Guide

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The Franklin Institute
Science Museum

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Dear Teacher,

Welcome to The Franklin Institute's exhibit on the science of sports! The Sports Challenge is an exciting exhibit that will help your students discover the vital roles that physics, physiology, and materials science play in a variety of sports.

What The Sports Challenge is About

The Sports Challenge is a fully interactive exhibit of fifteen sports stations that allows visitors to try sports as different as baseball and rock climbing. Each sports station focuses on a different scientific principle that is crucial to making the sport work. For example, a pneumatically rocked surfboard challenges the visitor to figure out how to stay balanced by experimenting with different foot positions—and in the process teaches that a narrow base of support (feet together) is the least stable position.

Many of the stations in The Sports Challenge demonstrate how scientists work, by asking visitors to change one part of a complex activity to test what will happen. For example, in the pitching challenge, visitors may compare how fast they can throw three balls of different sizes but approximately the same weight in order to see the effect a ball's size has on how fast it moves through the air. This is just one of the opportunities that students will have to simulate how scientists work—collecting data and looking for connections between cause and effect.

Other sports stations allow the visitor to explore how using one's arms can increase momentum and how friction helps a person climb a rock. There are also displays that demonstrate what happens in an athlete's body the more they work out, how spin is used in sports, and much more.

Teacher Support

This Teacher's Guide will help you and your students get the most out of your visit to The Sports Challenge. The Guide is divided into two parts. Part I is a two-page "In-Exhibit Exploration Activities" guide with questions to be answered as your students interact with the sports stations. The questions will help students focus on the scientific principles behind what they are doing. There is also a two-page answer sheet to use in checking their results.

Part II of the Teacher's Guide has thirteen in-class activities for further investigation of the science of sports. These activities can be used before your visit to generate student interest in the exhibit or once students are back in the classroom to capitalize on that interest for further science investigations.

Free Educator's Preview!

To help you prepare your class for visiting the Institute, you can get free admission to the museum in advance of your trip, just show your school ID (or a pay stub) at the Box Office of the Institute, and get in free. This offer is sponsored by the Philadelphia Inquirer and does not have any cash value towards the price of a field trip.

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Answers for In-Exhibit Exploration Activities

Part of the purpose of the In-Exhibit Exploration is to make sure that students have all done the same activities, to make it easier to discuss them as a group back at school. Here are the kinds of answers students are likely to come up with, although in many cases they may find alternative correct solutions. What's most important is that they can give an explanation for their answers and back them up with their observations.

Wider is Better (surfboard)

What is different about those three foot positions on the surfboard? Some are narrower than others. To stay balanced, a person has to keep his or her weight over the area between the feet. Making that area wide by keeping the feet apart makes the job easier.

Other examples of this principle in action include linebackers in football trying to hold their position, batters in baseball getting ready to swing, and tennis players, fencers, and sumo wrestlers being able to shift their weight without falling.

Get a Grip (rock wall)

Students should notice the difference in smoothness between the high-friction half of the wall and the low-friction half. Examples of how friction is used in sports include a baseball player sliding into a base to slow himself down, a basketball player gripping a ball, and a runner at the start of a race pushing against the ground to move forward. Any sport that involves having two materials touch/push/rub against one another uses friction.

Go Speed Racer (wheelchair race)

The 3-wheel racing wheelchair is built to go as fast as possible, and to get the maximum effect from an athlete's arm muscles. The regular wheelchair is meant to be sturdy and easier to get into and out of. Some of the other differences are size, number, and tilt of the wheels; height; shape; and ease of getting started.

Take a Leap (vertical leap)

Back in class, have students share their results and make a table showing how high each student jumped with their arms unmoving, and while swinging their arms upwards. How much of a difference was there on average? Have students identify any readings that the readout may have made an error on—scientists also have to analyze their data for mistakes.

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Answers for In-Exhibit Exploration Activities (continued)

In for Spin (ice skating)

Students should notice themselves spinning faster when they pull their leg in toward their body. This illustrates the principle that the tighter the circle their limbs move in, the smaller the distance is around the circle—and the more times per second that they go around the circle. Ice skaters use this effect by bringing their arms and legs in close to their bodies as they spin. Somersaulting divers and gymnasts also use this principle.

The Way the Ball Bounces (basketball)

In general, harder surfaces will absorb less energy from a ball than a soft surface, allowing the ball to bounce higher. Back in class, have students compare their results to see if they all got the same answer. Ask for possible reasons for any differences. Could the ball have bounced differently for different students? Possible answers might include differences in the force used to dribble the ball, “funny” bounces off an uneven surface, and dropping balls from different heights.

And They’re Off (drag racing)

“Practice makes perfect” is an adage that refers to the brain’s ability to learn patterns and respond more quickly to them. The five trials of the drag race give the brain a chance to get used to the “3—2—1—Go” countdown. It takes .12 seconds for a signal to travel from brain to foot. For anyone to record a faster time than that, he or she actually has to send the push signal to the foot before the “Go” light goes on!

Flaming Fastballs (pitching cage)

A pitched ball begins to slow down as soon as the pitcher lets go of it because of air resistance—air dragging on the ball. The bigger the ball, the more air pushes against it. On the other hand, the weight of a heavy ball helps it resist slowing down. Back in class, have students share results and calculate the average speed with which the class threw each ball. Which ball did most students predict would go fastest? Which of the factors about balls—size or weight—seems to have had the greater effect on the class’s throws?

Speed Skiing (skiing)

Athletes can adjust their bodies into special positions:

- to take advantage of certain muscles, for example, on the surfboard and in the pitching cage
- to help their bodies move faster/further, for example, ice skating and leaping
- in response to the shape of some external object they are trying to fit into, for example, the racing wheelchair and the rock wall
- to keep their balance, for example, on the surfboard

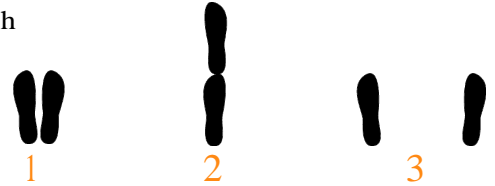
Students may suggest other reasons as well. Accept any answer that can be supported by a reasonable explanation.

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In-Exhibit Exploration Activities

Wider is Better (surfboard)

Being able to keep your balance is an important skill in many sports such as surfing! Here are three different foot positions to try when standing on the surfboard. Which do you think will make it easiest to keep your balance? Circle that foot position.



Now try each position. In which position was it the hardest to maintain your balance? _____
In which position was it the easiest? _____

List two other sports in which you have seen athletes stand in the “easy” position.

When do athletes take the “easy” position?

Get a Grip! (rockwall)

Many sports are affected by friction, a force that makes objects stick against one other.

Climb as far across the rock wall as you can, going from left to right.

What is different about the second half of the wall?

List at least three sports that use friction, and then tell how each sport uses the principle of friction.

SPORT

HOW FRICTION HELPS

Take a Leap (vertical leap)

Athletes can improve their chances of jumping higher by how they hold their bodies.

Make two leaps:

1. keep your arms at your sides for one
2. throw your arms upwards for the second leap.

For each leap, record how high off the ground you. You will need this information to make a table when you get back to class.

JUMP #1: _____ inches _____ seconds (arms at sides) JUMP #2: _____ inches _____ seconds (arms moving)

Go Speed Racer (wheelchair race)

Equipment is usually designed for a specific purpose.

List all the differences you see between these two wheelchairs:

Choose one difference and explain why you think the wheelchairs were designed with that difference.

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In-Exhibit Exploration Sheet
(continued)

In for Spin (ice skating)

Do you know how to spin faster? Stand on the platform on one leg and then spin.

What happens when you spin on the platform with one leg sticking out?

What happens when pull your leg in and tuck it into your body?

List at least two sports where you have seen an athlete do the same movement.

The Way the Ball Bounces (basketball)

Bounce the basketball and then rank the surfaces from bounciest to least bouncy.

Use a scale of 1 to 4 with 1 being the bounciest.

Foam: _____ Sand: _____ Wood: _____ Astroturf: _____

Why was it difficult to bounce the ball on some surfaces?

And They're Off (drag racing)

Response time is important in many sports. Try this challenge and you will get five chances to see how quickly you can "step on the gas."

Record your time below for each of your five tries or put an "X" if you got a "too early" warning.

#1: _____ #2: _____ #3: _____ #4: _____ #5: _____

Did your response time change? Did you get faster or slower? What might have caused the change?

Flaming Fastballs (pitching cage)

Predict which ball you will be able to pitch the fastest.

What about that ball makes you think it will go the fastest?

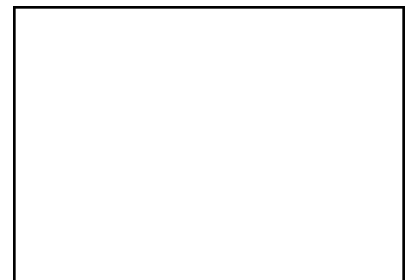
How fast did you actually throw each of the three balls?

Biggest ball: _____ Medium-sized ball: _____ Smallest ball: _____

Speed Skiing

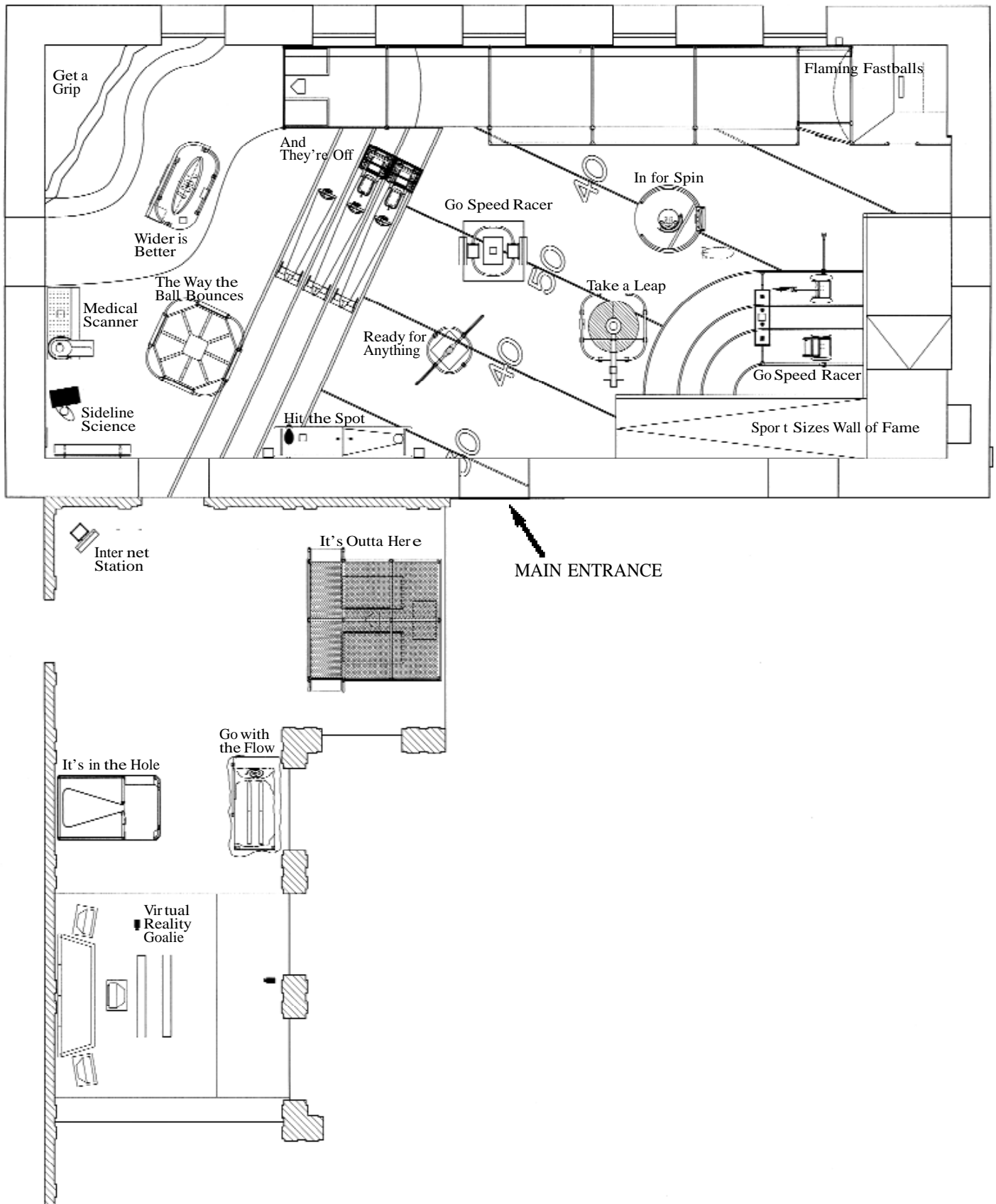
To raise their speed, skiers adjust their bodies into a special position reduce air resistance. Look through the exhibit at other sports challenges and find another sport in which people are putting their bodies in special positions that help them perform better. Draw what the people look like in that position. (You can use a stick figure.)

Write at least one advantage of the person's putting his or her body in that position for that sport.



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Exhibit Layout



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In-Class Activity: Design a Sport to Be Played at Zero Gravity

Science Standards and Concepts

Extrapolating science data from experience;
Motion

Skills

Cooperative work, Drawing conclusions,
Recognizing cause and effect, Predicting,
Creative writing

Suggested Time

1 class period

Materials

Paper and pencils

Background

In space, people have to deal with the lack of gravity, which causes objects to keep moving in a straight line rather than falling back to ground and stopping. The lack of gravity means that things will not stay put if there is the slightest breeze or vibration to move them. Outside the space station, lack of air, high temperatures from the bright Sun and cold temperatures in the shade, and the danger of equipment floating off into the distance should all be concerns for would-be designers.

Procedures

1. Ask students what differences they can name between ice hockey and field hockey, or between cross-country running and running on a track. Can students think of other sports that have variations when played on different surfaces, in different locations, or under different conditions? How does the sport change in each situation?
2. Discuss what the conditions would be like if students were living in a space station orbiting the Earth. Based on watching television coverage of the space shuttles and space stations, what can students say about how being in space is different from being on Earth? The major factor

they should mention is the lack of gravity. Ask them what effect the lack of gravity has on the way people can live in space.

3. Assign small groups to work together to design a sport that might be played at a space station with zero gravity. Students can adapt a sport played on Earth or design a totally new one, but in designing their game, they must deal with the lack of gravity. They should determine the object of the game, the number of players, the equipment needed, including any special gear that does not currently exist, and the name of the game.

4. Once the design of the game has been finished, each team should write a brief description of the sport and attach one or more illustrations showing what the game would look like as it is played. Have each team report on its sport to the rest of the class.

5. During the debriefing after each team has reported, be sure the team is asked how it had to change the sport to deal with the conditions on the space station. How did the team decide how the sport would work? What problems did the team have to overcome? Once all reports have been given, ask the class what similarities were apparent among the different teams' sports.

Extending the Lesson

The NASA educational video *Astrosmiles* is a wonderful look at the day-to-day realities of living in zero gravity. It is available free from NASA by asking for a copy of this "Best of" series tape and mailing a blank 120-minute VHS tape to: NASA Teacher Resource Center, Building 1200, Stennis Space Center, MS 39529

In the Exhibit

Several of the stations in *The Sports Challenge* involve changing a sport in some way—removing the friction from part of the rock wall, bouncing a basketball on unusual surfaces, etc.

THE SPORTS CHALLENGE

In-Class Activity: The Equipment Puzzle

Science Standards and Concepts

Relationship between an object's form and its function; Engineering, Design

Skills

Cooperative work, Observation,
Drawing conclusions

Suggested Time

Part of a class period

Materials

Copies of next page "Strange Sports Equipment"

Procedures

1. Divide the class into pairs or small groups. Duplicate and distribute to each group a copy of the sheet showing unusual sports equipment.
2. Explain that the students are to try to determine what the items are designed to do and how an athlete might use them, rather than the sport in which each is used. Students should focus on size, shape, materials, and parts.
3. Guide students with questions such as
 - What features do you notice about each object? How do these features offer clues about its purpose?
 - Does the item remind you of anything else?
 - How does the shape of a familiar object, such as a catcher's mitt or a ski, tell you about how it is used?

Remind students that they are to focus on what the object tells them about itself.

4. Regroup and discuss each of the items in turn.

Answers

Top item: Padding for hockey goalies; protects players by absorbing impacts; worn under their uniforms

Item on the right: Disc used in curling; gripped by the handle and slid along the ice; heavy weight helps it keep going and knock away other discs.

Bottom item: "Monofin" that fits over both feet. Pushes large amounts of water quickly to help swimmers travel fast.

Item on left: Scoop used for catching and throwing balls in jai-alai; straps attach it to the hand and let players catapult balls at very high speed.

In the Exhibit

Ready for Anything is a statue wearing 25 different pieces of equipment from various sports, including a jai-alai scoop and goalie padding. If you are using this activity before your visit, ask students to be on the lookout for these items. If you are using this activity after your visit, ask which ones the statue was wearing. Each piece of equipment on the statue provides clues about how it is used.

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Strange Sports Equipment

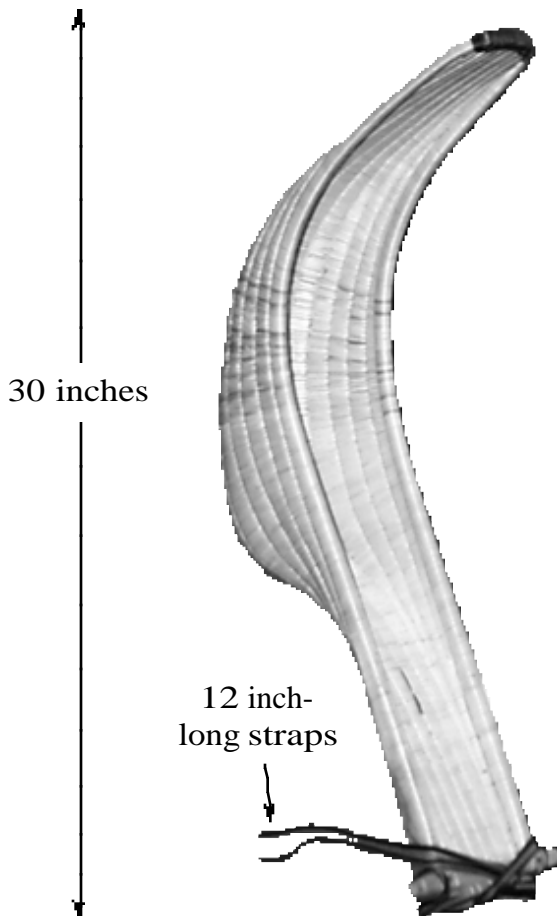


One inch thick padding

44 pound stone disc



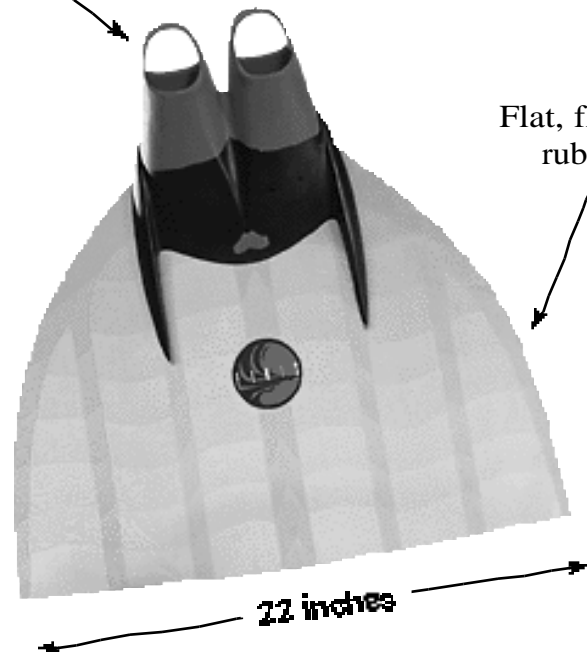
11 inches



30 inches

12 inch-long straps

Hollow areas



Flat, flexible rubber

22 inches

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In-Class Activity: Walking the Y

Science Standards and Concepts

The wider the base, the more stable the position; Balance and Stability

Skills

Observation, Drawing conclusions, Recognizing cause and effect

Suggested Time

Part of a class period

Materials

Masking tape or other nontransparent tape

Procedures

1. Lay out three lines of tape on the floor in the shape of a very long and narrow “Y”. It should be about 25 feet long and 2 feet wide at its widest end. You will need the third piece of tape to make the stem part
2. Have students try to walk along the “Y” from the top, or open part, to the bottom, keeping their feet within or touching the lines. They will have to bring their feet closer and closer as the lines converge.
3. Ask students what they notice as they walk along the “Y”. Some questions might be:
 - How does your foot position change?
 - Did you use other parts of your body?
4. Once all students have walked the “Y” (or several volunteers) ask: What sports require players to stay balanced when something—either another player or gravity—is acting to tip them over? Some possible answers might be football, rugby, ice skating, gymnastics.

Extending the Lesson

Here are some additional things that students can do to test their balance and learn what makes them more stable.

- Have students see how far they can lean over to the side with their feet together compared to with their feet apart. In both cases, draw a box around the student’s feet. Can they discover the connection between the boxes and their stability? The answer is that the box shows how far they can shift their weight before they start to topple.
- Explore some other ways to help them keep their balance. What effect can their arms have on keeping their balance? Their eyes? Other parts of their bodies?
- Use clay, blocks, or other building materials to construct structures that are the same height but have narrower or wider bases. Test their stability by seeing how easy they are to push over. The “Y” is designed to bring your feet closer and closer together; how does that relate to this building activity?

In the Exhibit

Wider Is Better shows the importance of having your feet wide apart on a real-life balancing activity—standing on a surfboard. Students will have fun trying to stay upright while the surfboard tilts up, down, and sideways—and will learn through experience that keeping their feet apart improves their ability to balance.

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In-Class Activity: The Reaction Time Challenge

Science Standards and Concepts

Interactions between senses and the brain;
How the brain follows patterns; Reaction Time

Skills

Cooperative work, Observation, Drawing
conclusions, Recognizing cause and effect,
Computing averages

Suggested Time

Part of a class period

Materials

1 copy of the drop strip on next page for every
two students (make extra copies in case any
strips become torn or too crumpled to use)

Procedures

1. Divide the class into pairs and give each pair a copy of the drop strip. One person will be the timer and the second person will be the racer. The pair will reverse positions so each person has a chance to time his or her reactions.
2. The timer holds the drop strip from the top, letting it hang down in front of him- or herself. The racer places one hand at the bottom of the drop strip but not touching it. The racer's thumb is on one side of the strip and the index finger on the other side. The fingers are about an inch apart, as though they were about to pinch the strip.
3. The timer drops the strip suddenly, and the racer tries to pinch it as quickly as possible. Where the racer's fingers grab the strip indicates how quickly the racer was able to react, from zero seconds to almost a quarter of a second. Have the racer try three times to get an average.

4. Now, have the timer give a steady countdown of "3—2—1—Go!" before dropping the strip. Have them do this three times to get an average.

5. Have racer and timer switch and repeat the two steps.

6. Ask students the following questions:

- Does the racer's time change when given a countdown? Why?
- Human brains are built to seek out patterns like the countdown. What other patterns occur in sports?
- Why will an athlete get better at the sport once he or she gets used to recognizing and acting on the pattern?

Extending the Lesson

Have students take the strip home and ask some adults to try the activity with them to find out if adults' reaction times are better than that of students. The class could also test the reaction time of some athletes. They might consider whether runners on the school's track team have better reaction times than players on the baseball team.

In the Exhibit

And They're Off puts students in the driver's seat of a hot rod at the starting line of a drag race. When the countdown lights in front of the driver reach green, the driver steps on the gas, and a timer shows how quickly the driver was able to react. By trying it multiple times, the driver will improve, as his or her brain learns to anticipate the green light.

_____ .22

_____ .20

_____ .18

_____ .16

_____ .14

_____ .12

_____ .10

_____ .08

_____ .06

_____ .04

_____ .00 sec.

DROP STRIP—how many seconds long is your reaction time?

_____ .22

_____ .20

_____ .18

_____ .16

_____ .14

_____ .12

_____ .10

_____ .08

_____ .06

_____ .04

_____ .00 sec.

DROP STRIP—how many seconds long is your reaction time?

_____ .22

_____ .20

_____ .18

_____ .16

_____ .14

_____ .12

_____ .10

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_____ .06

_____ .04

_____ .00 sec.

DROP STRIP—how many seconds long is your reaction time?

_____ .22

_____ .20

_____ .18

_____ .16

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_____ .12

_____ .10

_____ .08

_____ .06

_____ .04

_____ .00 sec.

DROP STRIP—how many seconds long is your reaction time?

_____ .22

_____ .20

_____ .18

_____ .16

_____ .14

_____ .12

_____ .10

_____ .08

_____ .06

_____ .04

_____ .00 sec.

DROP STRIP—how many seconds long is your reaction time?

THE SPORTS CHALLENGE

In-Class Activity: Keeping It Cool

Science Standards and Concepts

Conducting scientific investigations; Transfer of energy; Evaporation; Human physiology

Skills

Observing, Measuring, Graphing, Drawing conclusions, Recognizing cause and effect

Suggested Time

Part of a class period

Materials

Four thermometers capable of measuring temperatures around room temperature, 2 spray bottles with water, stiff paper or cardboard for fanning, graph paper

Procedures

1. Tape the four thermometers numbered 1 through 4 to a wall at least three feet from one another. Do nothing to #1. Ask for three volunteers or appoint three students to vary the conditions for the other three thermometers. Have one student spray #2 with water every 20 seconds. Have a second student fan #3 constantly. Have the third student spray #4 every 20 seconds AND fan it constantly. You can select a volunteer timer, or do it yourself.
2. Have four more students record the temperatures of the thermometers every 20 seconds (right before spraying) for 5 minutes.
3. Have the class use this raw data to create graph on the board showing the range of temperatures for all four thermometers.

4. Ask students questions such as:

- Which thermometer cooled off the most?
- What observations can you make about each thermometer?
- What observations can you make about the combined graph?
- How does the human body naturally cool off when it gets hot?
- Why do you think that there are big fans on the sidelines at a football game?

Extending the Lesson

Try an evaporation experiment on your own hand. Spray water on the back of one hand and leave the other one dry. Blow on both hands and feel the difference. Could you change how cool your hand feels by blowing more strongly or more lightly on it?

In the Exhibit

Sideline Science shows different kinds of devices that football teams use to keep their players in shape during and after a game. One such aid is sports drinks with electrolytes. They help the body absorb water better as it loses fluids through perspiration.

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In-Class Activity: Official Bounce Testers

Science Standards and Concepts

Resilience (bounciness), Conservation of energy, Properties of objects and materials, Designing and conducting scientific investigations

Skills

Cooperative work, Observation, Measuring, Graphing, Drawing conclusions, Recognizing cause and effect

Suggested Time

1 class period

Materials

Balls from many sports (preferably not hard like golf balls): basketball, ping-pong, soccer, rugby, tennis...; one for each group of students

Procedures

1. Explain to students that their task is to compare the bounciness of the balls used in various sports. Brainstorm with students about what “bounciness” means and how to measure it. Have the class agree on what would be a fair test. As a group, have the class develop a plan for the procedure to follow and the measurements to take.
2. Divide the class into smaller groups and have each group conduct their tests and record their findings.
3. When every group has completed its investigation, reconvene the class and have groups share their results. Create a combined chart on the board.

4. Some questions to ask students are:

- Did the balls differ in their bounciness?
- Rank the balls from most bouncy to least bouncy.
- What features of the balls might make them bounce differently?
- What else could affect the way a ball bounces?
- Why might different sports want more or less bounce in their balls?
- How would a particular sport be different if the bounciness of its ball suddenly changed?

Depending on your school set up, you might take your class outside to try bouncing the balls against different surfaces such as grass, the sidewalk, or on a wooden tabletop.

Extending the Lesson

Explain that many sports have specific regulations about how much their balls may bounce. Post the list on the next page and have students test balls to see if they follow the regulations listed. (You might borrow some balls from the Health and Physical Education Department for student use.)

SPORT OFFICIAL BOUNCE TEST

Note that these official sports federations are mostly located in the United States, where they use inches rather than metrics.

Baseball	When dropped from 60 inches onto a hard wood surface, the ball should bounce to between 16" and 20"
Tennis	When dropped onto a concrete base from 100", the ball should bounce more than 53" but less than 58"
Basketball	When dropped on wooden court from 6 feet measured from bottom of ball, rebound 49-54" measured to top of the ball.
Lacrosse	When dropped onto a hard wooden floor from a height of 72", should bounce to a height of between 49" and 54".
Table Tennis	The standard bounce required shall not be less than 22 cm (8 3/4") or more than 25 cm (9 3/4") when dropped from a height of 30.5 cm (12") on an approved table.

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In-Class Activity: Playing It Safe

Science Standards and Concepts

Properties of objects and materials,
Abilities of technological design;
Energy, Force, Impacts, Safety

Skills

Cooperative work, Predicting, Observation

Suggested Time

1 to 2 class periods

Materials

Eggs, one for each small group; construction materials such as newspaper, string, rubber bands, tape, paper, straws, toilet paper—the more variety, the better; a scale that can weigh from several ounces to several pounds.

Procedures

1. Divide the class into sports safety teams of from three to five students. Explain that their job is to design a protective “safety suit” for a raw egg that will allow it to survive a collision with a wall, just as sports gear is designed to protect athletes’ bones and brains.
2. The “safety suit” can be no more than six inches wide, high, or deep, and must have a way for the egg to get in and out without too much difficulty. The teams must document their design in some way, with a drawing, blueprint, or step-by-step instructions for making the suit.
3. Allow the teams 20 to 40 minutes, depending on the schedule, to design and build their suits.
4. Once the teams have completed construction, move to the “collision site.” This is any area where you can stand 10 feet from a wall and throw the students’ suited-up eggs. If indoors, spread newspaper at the base of the wall in case some of the safety suits have flaws.
5. Have each team describe its suit and display its documentation. Then toss their suited-up egg

against the wall. If some of the suits are not strong enough to withstand impact, lead a discussion about what might have gone wrong in the design or execution of the safety suit.

6. Some general questions to ask include:

- How did each team decide on the materials to use?
- What features were similar in the all the designs?
- What were some unique features in the designs?
- What kinds of gear do you wear to protect yourself from impacts?
- What equipment do athletes in various sports wear to protect themselves from impact?

Extending the Lesson

1. Brainstorm with students what constitutes a good safety suit besides its ability to protect an athlete from injury. One possibility may be lightness. Ask students why athletes might care about the weight of their gear.
2. Have the teams “go back to the drawing board” to design a new safety suit with an additional criterion: it must be as light as possible—while still protecting the egg.
3. Place all the documentation from the previous designs in an area where students can refer to it. After another 20 to 40 minutes for designing and constructing the new safety suit, repeat the presentations and field tests. This time, however, weigh each safety suit (without the egg) before the field tests to see which successful suit is the lightest.

In the Exhibit

The Medical Scanner is a futuristic “medscanner” that displays the kinds of injuries that real athletes may suffer if they are not protected well enough from the impacts and other stresses of their sport.

THE SPORTS CHALLENGE

In-Class Activity:
Forward Mo!

Science Standards and Concepts

Position and motion of objects;
Momentum, Force

Skills

Cooperative work, Observation, Predicting,
Drawing conclusions, Recognizing cause
and effect

Suggested Time

Part of a class period

Materials

Tape measure(s), hand weights (optional)

Procedures

1. Introduce the term momentum, which is an object's tendency to keep moving. This activity will demonstrate how track stars use momentum to the full advantage.
2. Divide the class into teams of four to five students. Tape a line on the floor or draw a line outside on the ground for each team. Have one student at a time stand behind the line and then leap as far forward as he or she can. For this first part of the activity, students should jump with their arms kept at their sides. Have one teammate measure the student's jump, from the line to the tip of his or her toes, and another teammate record the distance. Teammates should take turns so that everyone has a chance.
3. Have students try leaping three times apiece in order to get a best distance.

4. For the next set of three leaps, have students try jumping with their arms behind them before they start, and then swinging their arms forward as they leap out.

5. Some possible questions to ask in the debriefing are:

- What did using your arms do to your distance?
- How have you seen athletes use their bodies to help them travel faster? Higher? Farther?

Extending the Lesson

Have students try this activity holding 3- to 5-pound weights in each hand and swinging their arms forward as they leap out. Ask students as a group to predict what will happen when they jump.

In the Exhibit

Take a Leap uses a laser detector to measure how high a person jumps during a vertical leap. In this sports station, students will be able to measure the difference in momentum that using their arms in a leap makes.

THE SPORTS CHALLENGE

In-Class Activity: Sports Measures

Science Standards and Concepts

Simple instruments provide more information than the senses. There are normal ranges for body measurements. Abilities of technological design; Measurement

Skills

Cooperative work, Categorizing, Predicting, Measuring

Suggested Time

One to two class periods

Materials

Standard classroom materials such as paper, scissors, tape, string, rubber bands, cups, water, cardboard and paper clips, plus whatever less common materials are available and will stimulate creativity

Procedures

1. Discuss with the class that athletes are measured for a variety of information. Their weight is frequently checked; their height is part of their published statistics.
2. Ask students to think of other measurements of an athlete that might be needed to give a complete picture of the athlete's health or abilities. Brainstorm a list with the class, and then winnow the list down to those ideas that might be measurable without using some high-tech device. For example, students might suggest that it would be useful to measure an athlete's peripheral vision.
3. Divide the class into groups and have each group work on designing a way to measure a different one of the functions or abilities they listed. Encourage the groups to come up with measuring devices that they could actually make. For example, a group might test peripheral vision with an eye test given to the left and right sides of a person.

4. Once the groups have completed their work, have them share their designs and explain both how they work and why that measurement might be important.

5. After presentations, discuss issues such as:

- How practical is each device?
- In which sports would this measurement matter a great deal? Why?
- In which sports would this measurement be of little importance? Why?

Extending the Lesson

The educational effectiveness of this activity will be greatly enhanced if you have students actually make their devices and try them out. When the measuring tools are displayed, ask the groups what unexpected problems they encountered when they tried to use their measuring tool. Based on their experiences, could the groups go "back to the drawing board" and improve on their design? How?

In the Exhibit

The Sports Sizes wall is a row of life-sized photos of real athletes, showing the variety of body shapes and sizes involved in the different sports.

Some possible sports measurements (to trigger thought if the class has difficulty getting started):

- How much air do their lungs hold?
- How accurately can they throw?
- How wide can they spread their hands?
- How quickly can they stop when running?
- How soft a sound can they hear?
- How tightly can they grip?
- How accurately can they judge distance?

THE SPORTS CHALLENGE

In-Class Activity: Men vs. Women

Science Standards and Concepts

Recognizing and analyzing alternative explanations

Skills

Cooperative work, Conducting research, Graphing, Extrapolating information from statistics, Hypothesizing, Drawing conclusions

Suggested Time

Parts of two class periods plus time to do research

Materials

Reference materials such as almanacs that list sports statistics and/or access to the media center's computers for research; a good site for students is <http://www.infoplease.com/sports.html>

Procedures

1. Divide the class into research teams and give each team a sport to do research about. The sports must be ones that both men and women play. Some possibilities include the many events in track and field, speed skating, downhill skiing, swimming, and paralympics. Your own school may keep records on its athletic competitions and could be added to the list for research.
2. Students must find statistics related to men's and women's performances in their sport for ten different years. Students should record the best men's scores/times and the best women's scores/times. Then each research team should graph their results.
3. Have the teams share their graphs and compare data.

4. Among the questions to ask in the debriefing are:

- Are there some sports in which the athletes are consistently improving their performance over time?
- Are there some sports in which there seems to be little improvement among athletes?
- In which sports are women's and men's records closest?
- How do you measure "closeness"?

Extending the Lesson

As a class, develop two theories to explain why many women's records are closer to men's records today than they were several decades ago. Possibilities might include that people are stronger and healthier than they used to be and that girls are given more chances to play sports. Discuss what evidence students would need to support each theory.

In the Exhibit

The Sports Sizes wall displays life-size photos of great athletes, male and female. Other photos around the exhibit reinforce the idea that both men and women engage in a wide range of sports.

THE SPORTS CHALLENGE

In-Class Activity: Push Power

Science Standards and Concepts

Conducting a scientific experiment;
Biomechanics, Measurement, Muscles and Forces

Skills

Predicting, Measuring, Observation,
Drawing conclusions

Suggested Time

1 class period

Materials

Bathroom scales, photocopies of next page

Procedures

1. Biomechanics is the science that studies how to use the human body's muscles and bones most efficiently. Explain that everyone's body can provide more or less force depending on how it is used. To demonstrate this concept, students will measure force related to the use of their arms.
2. Put a bathroom scale on a table or desk. You may need several depending on the size of your class. First have students test to see if the scale is working accurately. Have a student put a heavy book or other weight on the center of the scale and then move the object to the four edges. If the scale shows different results for the different positions, brainstorm a way to make sure that students get accurate measurements when they use the scale. (One possibility is to make sure that the students always touch the center of the scale.)
3. Now have students use the scale to test how hard they can push with one arm in the following positions. Have them record the number of pounds of force they pushed with. This is the highest number at which they can keep the scale steady; they should ignore 1-second peaks. They can use a picture like the one on the following page to record their results.

- Stand facing the scale at arm's length and push down on the scale as hard as possible.
- Turn around with their back to the scale, stick their arm out backwards over the scale, and push down.
- Stand way out to one side and push down on the scale.
- Stand up against the table facing the scale and push down.
- Stand sideways to the table with the scale by their hip and push down.
- Sit under the table, reach their arm up and over to the scale, and push down.

4. Reconvene the class and ask questions such as:

- What observations can you make from the measurements that you took?
- Why is knowledge about how hard someone can push in different positions useful to athletes?
- Is it equally useful to athletes in all sports? Why or why not?
- Is this knowledge useful to someone who designs sports equipment? How?

Extending the Lesson

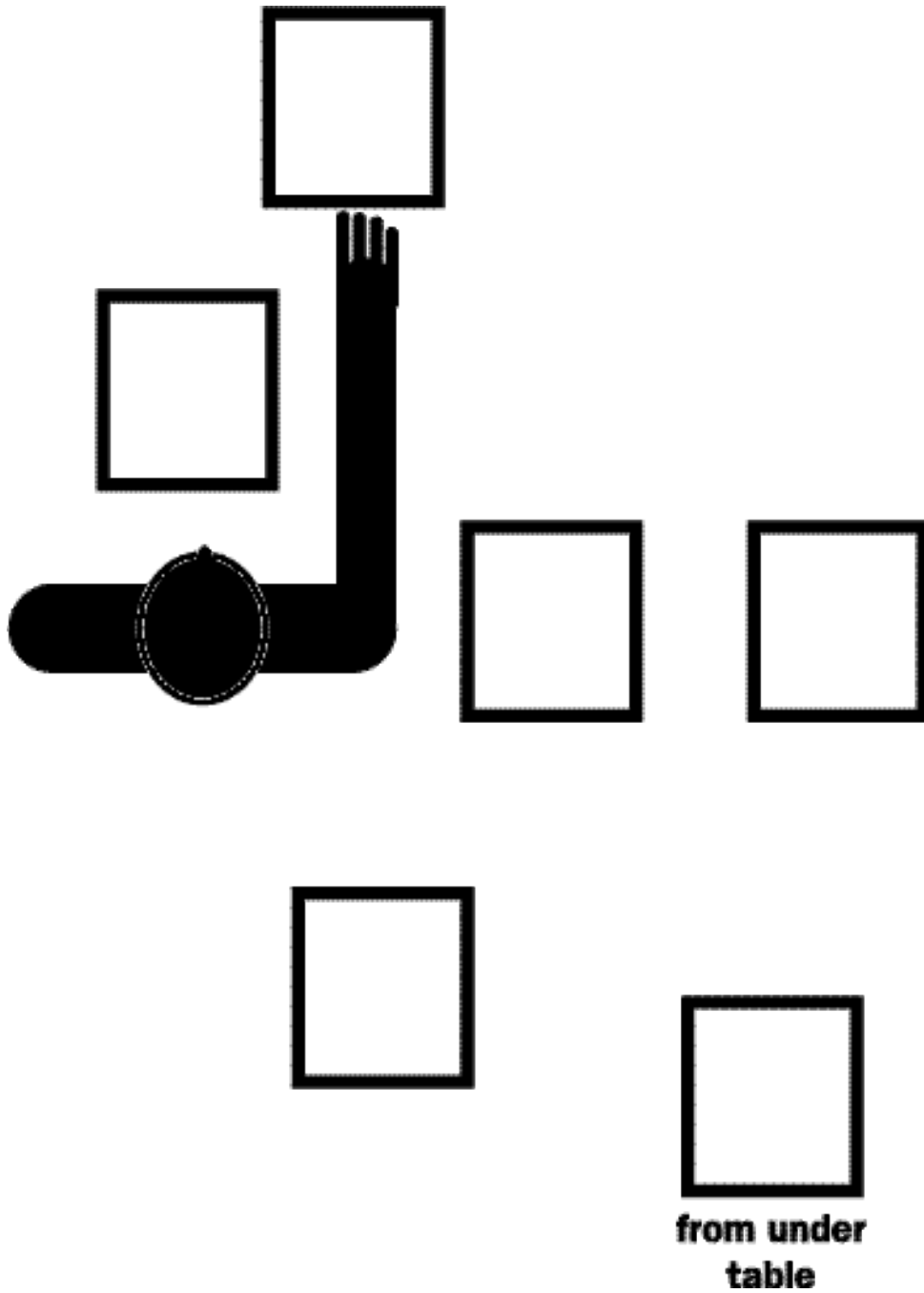
Have students predict where they should stand relative to the scale to get the strongest possible push. Then have them test their predictions.

In the Exhibit

Go Speed Racer is a race between two wheelchairs. One is a hospital chair and the other is a wheelchair that has been specially engineered to take better advantage of how arm muscles naturally push.

THE SPORTS CHALLENGE

In-Class Activity:
Push Power



THE SPORTS CHALLENGE

In-Class Activity: Dissecting a Ball

Science Standards and Concepts

Properties of objects and materials, technological design, finished objects are built up from simpler components

Skills

Observation, Predicting

Suggested Time

Part of a class period

Materials

Small saw, X-Acto knife, or kitchen knife;
non-hollow sports ball

Procedures

1. Pass around the ball and ask what students can observe about it using their senses. Can they tell anything about the inside? If they say 'no', prompt with some questions about what they can tell based on just feeling/hearing/seeing the ball's exterior: could it have liquid inside? Could it be solid steel inside? Styrofoam?
2. Begin taking the ball apart, cutting open the outside layer and examining the next layer down. Ask students if they can figure out what that layer is made of. How do they think that layer was put around the ball?
3. Work your way down layer by layer, comparing each with the ones already removed.
4. Once you have reached the center, ask students how many different materials the ball is made of.

Extending the Lesson

Based on their observations, can students try to construct a ball using classroom materials?

In the Exhibit

Along the pitching cage are panels showing the insides of baseballs and two different types of golf balls.

THE SPORTS CHALLENGE

In-Class Activity: Sports Inventions

Science Standards and Concepts

Technological design, science is a human endeavor that happens every day

Skills

Web searching, Writing and summarizing

Suggested Time

1 class period

Materials

Web-browsing computers

Procedures

1. Explain to the class that a patent is a detailed description of a new invention. The government grants them to the first person to come up with a new invention, and that gives them the right to be the only person allowed make that invention for a certain number of years. Many inventors sell their patent rights to bigger companies for lots of money, so a patent can be a valuable thing. New kinds of sports-related equipment are being invented every day, and they receive a lot of patents.

2. Have students do a web search for patents at <http://www.patents.ibm.com/> They should type one or two words about a specific sport into the search box (not just 'sports', or they'll get 8000 patents!). The ABSTRACT gives a short description of the invention. VIEW IMAGES (near the top) lets you see pictures of the invention.

3. Have each student select a patent which interests them and write a description of what it is and how it works in their own words. Have them include answers to the questions: What problem is the patent trying to solve? Is this patent similar to anything they've seen or heard of before? Can they think of a way this patent could be adapted to a different sport, or to something other than a sport?

Extending the Lesson

Many patents are only slight improvements to something that already exists; inventors don't always develop a totally new idea. Pick something in the classroom and brainstorm as a class how they could improve it.

In the Exhibit

The Revolutions in Sports wall shows off technologies that changed forever how certain sports were played. The Bionic Athlete displays prosthetic devices that allow paralympic athletes to run races and climb mountains. Other panels showcase the technology of golf balls and baseballs.