VOLUME 1

INSIDE:
Turn the page to learn more about our NEW Digital Assets!

STEM TENNIS

SUPPLEMENTAL CURRICULUM

GRADES 3 - 5 AND GRADES 6 - 8

Go Digital

In addition to the classroom, STEM Sports® K-8 Supplemental Curriculum is flexible and scalable to teach and implement at home and virtually on platforms such as Zoom, Google Classroom, Skype, and other digital learning tools. For each and every module, we provide solutions for successful remote learning with PowerPoint presentation decks and digital worksheets with keys. **To access these useful tools, visit www.STEMSports.com/tennisdigitaltools/**

Welcome

STEM Sports® provides turnkey K-8 supplemental curricula that use sports as the real-life application to drive STEM-based, hands-on learning in classrooms, after-school programs, and camps.

We are pleased to present Volume 1 of STEM Tennis, highlighted by the following:

- Content for a minimum of 16 hours of instruction that includes some healthy, physical activity.
- Turnkey kits equipped with all of the relevant sports equipment along with the necessary science supplies.
- Eight lessons aligned with Next Generation Science Standards (NGSS) and/or Common Core State Standards (CCSS) and/or National Standards for K-12 Physical Education.
- STEM.org Accredited™ Educational Experience approved
- 5E lesson plans so that students will develop 21st-century skills such as critical thinking, collaboration, creative problem-solving, and leadership.
- Differentiation: lessons for Kindergarten to 2nd graders, 3rd to 5th graders, and lessons for 6th to 8th graders.
- "Capstone" Project (Grades 6th to 8th) to commensurate student's knowledge of each curriculum.
- Assessments in each lesson to evaluate students effectively.
- Ready-to-use worksheets that align with each lesson and standards.
- A list of STEM-based, sports-related jobs pertinent to the lesson concept in each module.
- Engineering Design Process (EDP) woven into each curriculum.
- STEM Sports® glossary to support instructors and students as they come across key vocabulary in each module.
- Mindfulness Matters: important messaging to assist with the uniqueness of blending STEM with sports.
- Well-designed and scalable lessons for teachers, administrators, or volunteers.
- Professional development or training are not required.

Please visit www.STEMSports.com for additional information and to learn about all of the curricula that we offer.

We sincerely hope you and your students enjoy this STEM Sports® supplemental curriculum.

Please complete our Teacher Survey at www.stemsports.com/teacher-survey.
We appreciate your feedback.

Mindfulness Matters

Mindfulness may not be the first thing one thinks about STEM Sports®. However, mindfulness is essential to fully understanding the design and benefits of the STEM Sports® curricula by way of the following:

- Approximately 85% of STEM jobs anticipated for the year 2030 have yet to be invented.
- Moreover, within the next 10 years or so, 80% of all jobs will be STEM related.

The STEM Sports® curricula distinctly blends STEM content areas through hands-on/active play and sports. Active play provides a mechanism to teach STEM concepts; therefore, learning is integrated, engaging and meaningful as participants are exposed to STEM applications through real world experiences.

Teachers should be mindful of the fact STEM Sports® curricula are:

- Collaborative in nature, ensuring peer-to-peer learning opportunities
- Inquiry-based, allowing learners to discover information for themselves
- Designed for problem-solving: an essential lifelong skill
- Hands-on, engaging all types of learners
- Student-led, encouraging ownership of learning
- Active, promoting physical activity and wellbeing

Participants should be mindful of the fact STEM Sports® curricula are:

- Introduction to STEM concepts, facilitating comfort with STEM content areas
- Blending play and sport in an environment that is engaging, fun, and applicable to life outside the classroom
- Designed for all ensuring success for all participants – students do not have to be athletic or excel at science to accomplish curricula tasks
- Applicable to the real world where learning is meaningful for all participants

In sum, stakeholders should be mindful of all the STEM Sports® curricula have to offer. The unique design of the STEM Sports® curricula is essential to maximize learning and understanding of STEM concepts in sports and life applications.

 Dr. Vigil is an education consultant and mindfulness educator. For more information on mindfulness training for your school/organization, visit www.RayeEducationalServices.com or call 602-510-0298.

Contents
Grades 3-5

Module 5.0

May the Force be with You!

Objective

Students will design an experiment that collects evidence on gravity and pushing forces on two different tennis motions. Students will justify their explanation using key terms of balanced and unbalanced forces.

Concept

Science: Balanced and Unbalanced Forces
Use of Technology

Time

(2) 45-minute sessions

Module 6.0

Stroke of Energy

Objective

Students will experiment with the functionality and energy of a tennis ball by hitting it underhand and overhand. Students will explore and define the relationship between the velocity and energy of a tennis ball.

Concept

Science: Energy

Time

(2) 50-minute sessions

Module 7.0

Let's Serve

Objective

Students will learn the rules and strategies of serving in tennis. Students will use technology to find the speed of their serve. Students will analyze the speed and accuracy of their first serve to compare to their second serve.

Concept

Math: Decimal Notation for Fractions
Use of Technology

Time

(2-3) 45-minute sessions

Module 8.0

Advancements in Tennis

Objective

Students will examine the use of instant replay in tennis. Students will evaluate instant replay technology by brainstorming and developing a list of criteria and constraints. Students will write a letter based on their findings to determine if the needs of all stakeholders are being met.

Concept

Engineering: Criteria and Constraints of Technology
Use of Technology

Time

(2-3) 50-minute sessions

Contents

Grades 6-8

Module 5.0
May the Force be with You!

PAGE 80

Objective
Students will calculate the force used in two different tennis motions using Newton’s Second Law. Students will explain how a change in force affects the acceleration of the ball (when mass remains constant) by using experimental data to support a claim.

Concept
Science: Force, Acceleration, and Mass (Newton’s Second Law)
Use of Technology

Time
(2) 50-minute blocks

Module 6.0
Stroke of Energy

PAGE 84

Objective
Students will explore the relationship between Kinetic Energy and Velocity by experimenting and recording distance and time. Students will calculate and graph their experimental data to demonstrate/interpret the correlation of kinetic energy and velocity.

Concept
Science: Kinetic Energy

Time
(3) 50-minute blocks

Module 7.0
Let's Serve

PAGE 88

Objective
Students will learn the rules and strategies of serving in tennis. Students will use technology to find the speed of their serve. Students will analyze the speed and accuracy of their first serve to compare to their second serve.

Concept
Math: Percentages
Use of Technology

Time
(2) 50-minute blocks

Module 8.0
Advancements in Tennis

PAGE 92

Objective
Students will examine the use of instant replay in tennis. Students will evaluate instant replay technology by using steps of the Engineering Design Process, such as brainstorming and developing a list of criteria and constraints. Students will write a letter based on their findings to determine if the needs of all stakeholders are being met.

Concept
Engineering Design Process
Use of Technology

Time
(2-3) 50-minute blocks

Capstone

PAGE 97

Concept
Engineering Design Process

Objective
Students will use the Engineering Design Process to design a solution for getting more youth interested in Tennis, with a focus on challenges and obstacles for accessible playing areas.

STEM Tennis

Supplies Checklist

- ☐ **Six (6)** Penn Tennis Balls
- ☐ **One (1)** Ball of String
- ☐ **Six (6)** 25-Foot Tape Measures
- ☐ **One (1)** Radar Gun
- ☐ **Six (6)** HEAD Head Tennis Rackets
- ☐ **Six (6)** Digital Stopwatches
- ☐ **One (1)** SWEET SPOT Billie Jean King's Sweet Spot Eye Coach System
- ☐ **One (1)** STEM Tennis Supplemental Curriculum Manual

Materials Needed

- ☐ Pencils
- ☐ Colored Pencils
- ☐ Prototyping Materials *(Optional)*
- ☐ Tennis Court *(Module 7.0 Only)*
- ☐ Paper/Notebook
- ☐ Poster Board
- ☐ Smartphone/Tablet
- ☐ Various Sport Balls: Softball, Baseball, and Golf Ball
- ☐ Protractor
- ☐ Outdoor Space
- ☐ Calculator *(Recommended)*
- ☐ Various items to hit the Ball: Badminton Racket, Ping Pong Paddle, Baseball / Softball Bat.

Tennis

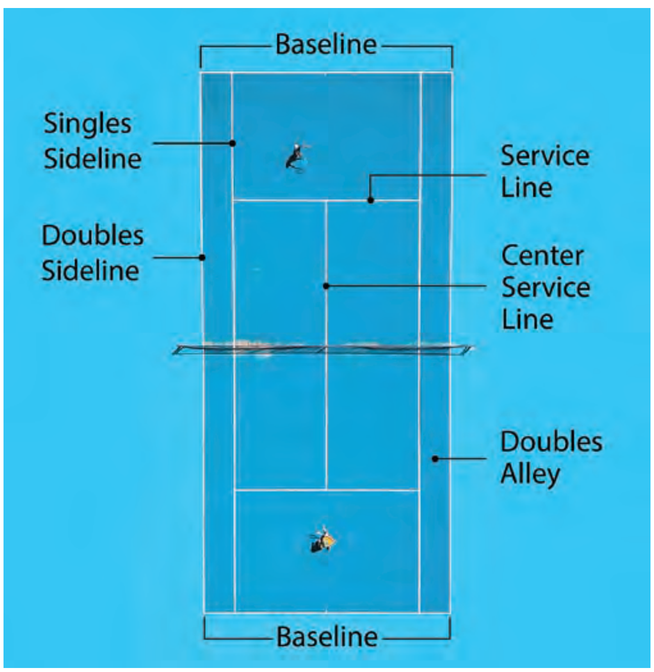
STEM Sports® Glossary

Angle: A figure formed by two rays that have the same endpoint.

Balanced Force: Two forces acting in opposite directions on an object, equal in size.

Baseline - Tennis Court: A 36 foot line that stretches along the short sides of a tennis court's rectangular shape. It is the area that forms the back boundaries of the court.

Center Service Line: A line on a tennis court that divides the two service boxes on each side.



Clustering: A group of data points with similar numerical values.

Coordinate Plane System: A two-dimensional plane formed by the intersection of a vertical line called the y-axis and a horizontal line called the x-axis.

Deuce: In the game of tennis, it is a tied score at 40-all that requires one player to get two successive points to win the game.

Doubles Alley: This is the area between the singles and doubles sidelines on a tennis court.

Double Fault: Two faults in a row result in the receiving team earning a point, including the following actions and/or scenarios:

- **"Let"**: The ball hits the net and lands in the opposite service box; it doesn't count as anything. The server serves again.
- The ball may bounce once on your side before returning it to the other side. However, the ball does not have to bounce; it can be volleyed/hit before it bounces.
- Your racket or body may not touch the net.
- A ball hitting the net and going over during play is live and playable. When playing doubles, partners do not have to alternate shots.

Doubles Sideline: This is the outermost line that runs the length of the entire tennis court.

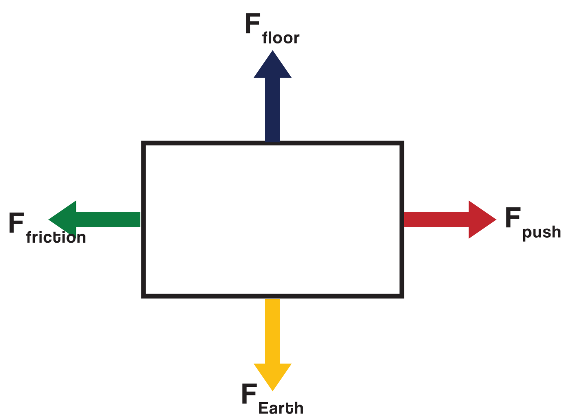
Engineering Design Process: An organized series of steps that engineers use to develop functional products or processes.

Fault: If the serve does not land in the correct service box, the serving player will get two chances to serve correctly into the service "opposite" box.

STEM sports
science • technology
engineering • math • sports

STEM Sports® Glossary

Force Diagram: A diagram showing all the forces acting on an object, the force's direction and its magnitude.



Graphite: A naturally occurring, steel-gray to black, crystalline form of carbon. Graphite is used in pencils and paints and as a lubricant and electrode.

Source: For the American Heritage Dictionary definition: graphite. (n.d.) American Heritage® Dictionary of the English Language, Fifth Edition. (2011). Retrieved November 4 2021 from https://www.thefreedictionary.com/graphite

Kinetic Energy: The energy an object possesses due to its motion.

Line (Segment): The part of a line with two endpoints.

Line of Symmetry: A line that passes through the center of an object or shape.

Unbalanced Force: A force that changes the position, speed, or direction of the object to which it is applied.

Line (Segment): The part of a line with two endpoints.

Line of Symmetry: A line that passes through the center of an object or shape and divides it into matching parts.

Linear Association: A straight-line linked between two variables.

Love: In the game of tennis, it represents a score of zero for each player.

Negative Correlation: When two variables move in opposite size and direction of each other, so as one increases the other decreases.

No Correlation: When no statistical relation exists between variables.

Nonlinear Association: When two variables form a pattern that is not close to a straight line in a scatter plot.

Outliers: A data point or set of results on a graph that is significantly larger or smaller than the next closest data point.

Paddle: Sports equipment with a small wooden handle and flat surface at the end used to hit the ball in various games, such as table-tennis or pickleball.

Parallel: Lines, planes, surfaces, or objects that are side by side, having the same distance continuously between them.

Perpendicular: A 90 degree angle to a given line, plane, or surface.

Point: An element in geometry that has position but does not extent.

Positive Correlation: When two variables move in the same direction.

Pythagorean Theorem: A statement about the sides of a right triangle. One of the angles of a right triangle is always equal to 90 degrees. This angle is the right angle. The theorem written as an equation is $a^2+b^2=c^2$.

Right Angle: An angle of exactly 90° that corresponds to a quarter turn.

Serving: The game begins with a SERVE. One person serves the whole game. Serving starts from the right hand side of the court and the serve must land in the diagonal service box. After a point is scored, the server moves to the other side (left hand side of the court) to serve. The receiving team cannot change sides.

Service Line: The line on a tennis court that runs parallel to the net, marking halfway or midpoint between the net and baseline. It is 27 feet wide.

Singles Sideline: The line that runs perpendicular to the net that signifies the side boundaries of a tennis court for singles matches. These lines are 39 feet long.

Tennis Racket: Sports equipment consisting of a handle and oval frame with tight interlaced strings used to hit the ball.

Unbalanced Force: A force that changes the position, speed, or direction of the object to which it is applied.

Velocity: The rate of change of position with respect to time.

$$\text{Velocity} = \frac{\text{s (displacement)}}{\text{t (time)}}$$

Modules

Module 1.0

GRADES 3-5

The Game Evolved

Concept
Science: Energy, States of Matter, and Observations

Objective
Students will answer text-dependent questions about the evolution of the equipment used in tennis. Students will analyze the pro's and con's of the design of tennis equipment over time.

Time
(2) 45-minute sessions

Standards

Next Generation Science Standards Connections

4-PS3-4. Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.

5-PS1-3. Make observations and measurements to identify materials based on their properties.

National Standards for K - 12 Physical Education Connections

Standard 1: The physically literate individual demonstrates competency in a variety of motor skills and movement patterns.

Standard 4: The physically literate individual exhibits responsible personal and social behavior that respects self and others.

Supplies Provided
Worksheets, Tennis Rackets, and Tennis Balls

Please email Info@STEMSports.com to access Worksheet Keys.

Materials Needed
Pencils, various Sport Balls: Softball, Baseball, and Golf Ball; various items to hit the ball: Badminton Racket, Ping Pong Paddle, Baseball / Softball Bat.

Video
How they make Tennis rackets:
stemsports.com/resources/resources-tennis/

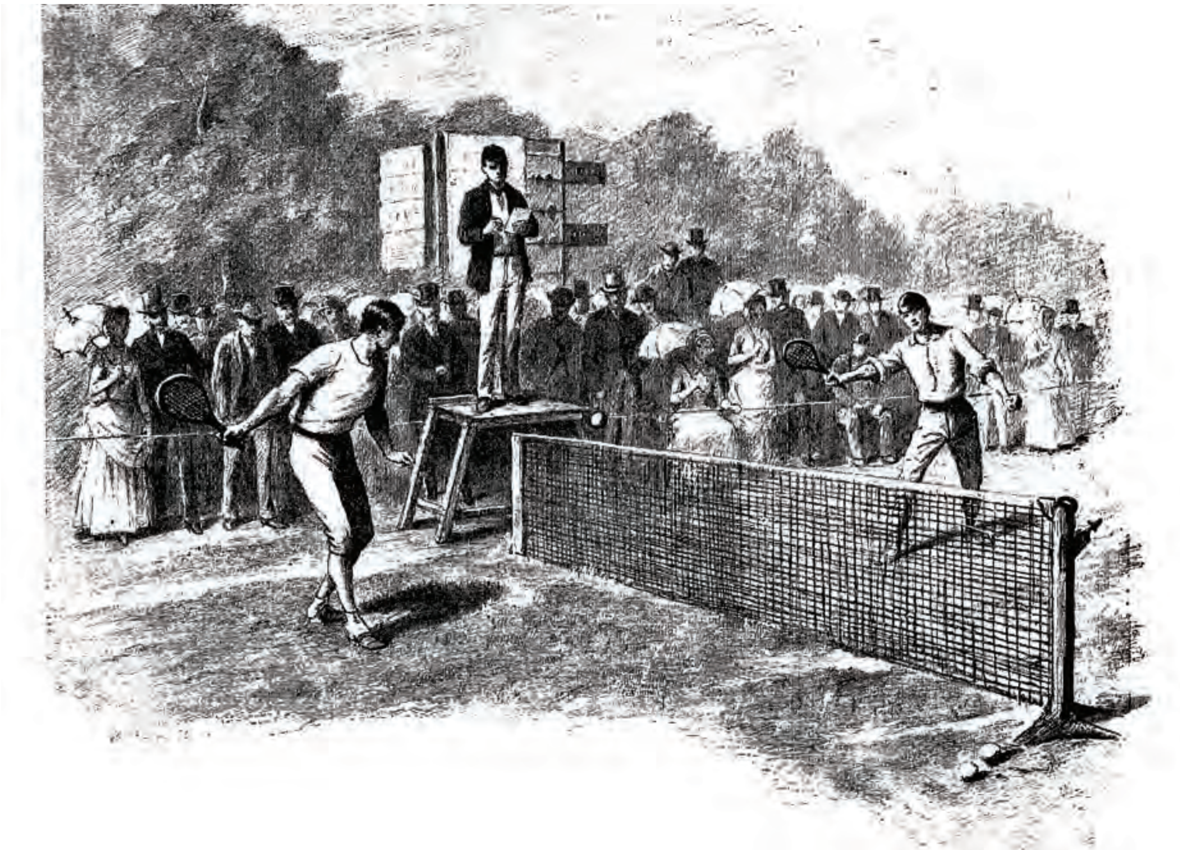
Sequence of Lesson

Have your students take this lesson's assessment prior to engaging by visiting:
www.stemsports.com/assessments
If you have limited digital capability, please email Info@STEMSports.com to access the Assessment & Key.

Engage: Ask students to observe a tennis racket and tennis ball. Have them discuss the traits of the racket and ball. How are these traits unique to the sport of tennis?

Explore: Have students read the article on pages 14-15 of "The Game Evolved." After reading the article, have students watch the video on how they make tennis rackets, which can be found at STEMSports.com, then click on STEM Tennis under Resources.

The Game Evolved



The game of tennis and its equipment has changed greatly since its introduction in France during the 12th century (1101 - 1200). In the early days of the game, players would play on a hard circular surface such as wood or stone, and would hit a wooden ball back and forth with their bare hand over a rope stretched from one side to the other; however, this style of game caused too many injuries. As a result, players began using leather gloves and leather balls toward the end of this century.

In the 13th century, the glove design evolved, players began using teardrop shaped wooden paddles with no webbing. These paddles were heavy, not flexible, and proved to be an insufficient design.

In the 14th century (1301 - 1400), the design of the paddle really changed to the racket we see today. The design was a long wooden handle with a raindrop wooden frame that was connected by strings. The addition of the strings increased the distance and bounce of the ball, which improved the overall game. In addition to the new and improved racket, a new type of cork ball was used; this ball was tightly wrapped with fabric and then covered in cloth.

The equipment in the game of tennis remained the same until 1850 when Charles Goodyear introduced a new process that made rubber stronger, allowing the ball to be bouncier and used on all types of playing surfaces. Twenty years later, Walter C. Wingfield took Goodyear's solid rubber ball design and found that if the rubber ball was hollow (empty on the inside), filled with air, and covered by a rubber cloth, the bounce and quality of the ball greatly improved.

Popular tennis companies, like Penn, took these ideas and continued to improve the performance of tennis balls over the next few decades. In 1970, Penn released their "play-rated" balls. These are unique tennis balls designed to maximize the play on different court surfaces and high altitude areas.

In 2001, they released a tennis ball with SMART OPTIK felt that increases visibility. In 2010, Penn introduced multiple 10 and under tennis balls specifically designed to encourage more kids to play tennis; these balls were lower pressurized balls that allowed for longer rallies, making tennis more fun. In a joint venture with the USTA, smaller rackets were also introduced for this age group. By 2011, Penn introduced their longest lasting tennis ball featuring Encore Technology, creating a ball lasting 22% longer than the previous one.

With several changes in ball design, Wingfield now decided it was time to focus on the racket. This original paddle design from earlier centuries inspired his very first tennis racket made in 1874; this racket was a large oval, made of solid wood and connected together by strings, a design used often over the next hundred years. By 1947, new technology allowed very thin layers of wood to be stuck together, which increased the overall performance of this racket design.

It is no surprise Wingfield is considered one of the "Founding Fathers" of tennis with all of his contributions to the equipment in the game; however, he is also responsible for coming up with the idea for the game of tennis. He provided many of the concepts, rules, and designs of the game. The most significant change in the engineering design of the racket occurred in 1967, when Wilson released the very first steel racket, T2000. The head of the Head Classic Racket was double the size of the models that came before it. Although much bigger, it was still much lighter and easier to swing than wooden rackets of the past.

Wilson's design inspired other engineers to try and improve the metals used in the racket. After years of testing and redesign, a breakthrough happened in 1976. Graphite was found to be the best metal for the racket: it is light and strong. Since this breakthrough to graphite, rackets haven't changed too much. Rackets today are simply a combination of different alloys, ceramics, and fiberglass to meet the needs of the individual player

The equipment and game of tennis has been the same now for many years. However, current-day technology used throughout the world is changing faster than ever before. What will be the next big change to the game of tennis? And will these changes improve the game as players, officials, and spectators see it?

Sources: https://medium.com/lantern-theater-company-searchlight/the-evolution-of-tennis-2b1b4b99e93f

https://www.thoughtco.com/who-invented-tennis-1991673

Explain: Review key terms: Tennis Racket, Paddle, and Graphite, which can be found in the STEM Sports® Glossary in the front of the manual and at STEMSports.com under Resources. Explain how the availability of materials has played a role in the evolution of the tennis racket and ball. Explain how engineers have to change their design based on the materials available to improve the overall design of the equipment.

Elaborate: Using the worksheet, answer the questions from the "The Game Evolved" article. Then have students summarize their learning by reviewing the timeline of the evolution of the tennis racket and ball. Discuss why some of these changes to the ball and racket used were necessary to the improvement of the overall game. For instance, why don't we use a lacrosse ball on a tennis racket? Why don't we use a pickleball paddle on a golf ball? Using the table provided, have students experiment by mixing different racket and ball options.

Teacher note:

Racket: potential options - tennis racket, hand, bottom of shoe, paddle

Ball: potential options - tennis ball, wiffle ball, golf ball, lacrosse ball

Evaluate: Have students record their data from the *Elaborate* activity on the table provided. Have students reflect and evaluate the pros and cons of different combinations.

Have your students retake this lesson's assessment to effectively evaluate their comprehension by visiting:
www.stemsports.com/assessments
If you have limited digital capability, please email Info@STEMSports.com to access the Assessment & Key.

Extend: Students could engineer their own racket and compare it to a standard racket:

- Would you make it longer/shorter and why? What advantages/disadvantages are created?
- Would you make it heavier/lighter and why? What advantages/disadvantages are created?
- Would you alter the frame: shape, size, material, etc.?
- Would you alter the grip: thickness, length, material, etc.?

STEM Jobs in Sports

- Tennis Chair Umpire
- Tennis Racket Engineer
- Manager: Sports Equipment Store
- Physical Education Teacher
- Sports Equipment Coordinator

Fun Fact

Tennis players used the palm of their hands to hit the ball back and forth over the net before the tennis racket was introduced.

Module 1.0

Name: ______________________________

The Game Evolved

GRADES 3-5

Elaborate

1. The paddle design in the 14th century is similar to the racket we use today. What were the strengths of this design? What were the weaknesses of this design?

2. What changes were made to the tennis ball over time?

3. What do you believe was Wingfield's most important contribution to the game of tennis?

4. Why is the introduction of graphite considered one of the biggest breakthroughs in the equipment of tennis?

5. What do you think will be the next big change to the game of tennis?

Module 1.0

Name: ____________________

The Game Evolved

GRADES 3-5

Elaborate

Describe how each ball would behave using some or all of the options provided. Think about the distances and bounce-ability of each racket and ball type.

Options	Tennis Ball	Golf Ball	Softball	Baseball
Tennis Racket				
Badminton Racket				

STEM sports science • technology engineering • math • sports

Module 1.0

Name: ______________________________

Options	Tennis Ball	Golf Ball	Softball	Baseball
Ping Pong Paddle				
Baseball / Softball Bat				
Bottom of Your shoe				
Other				

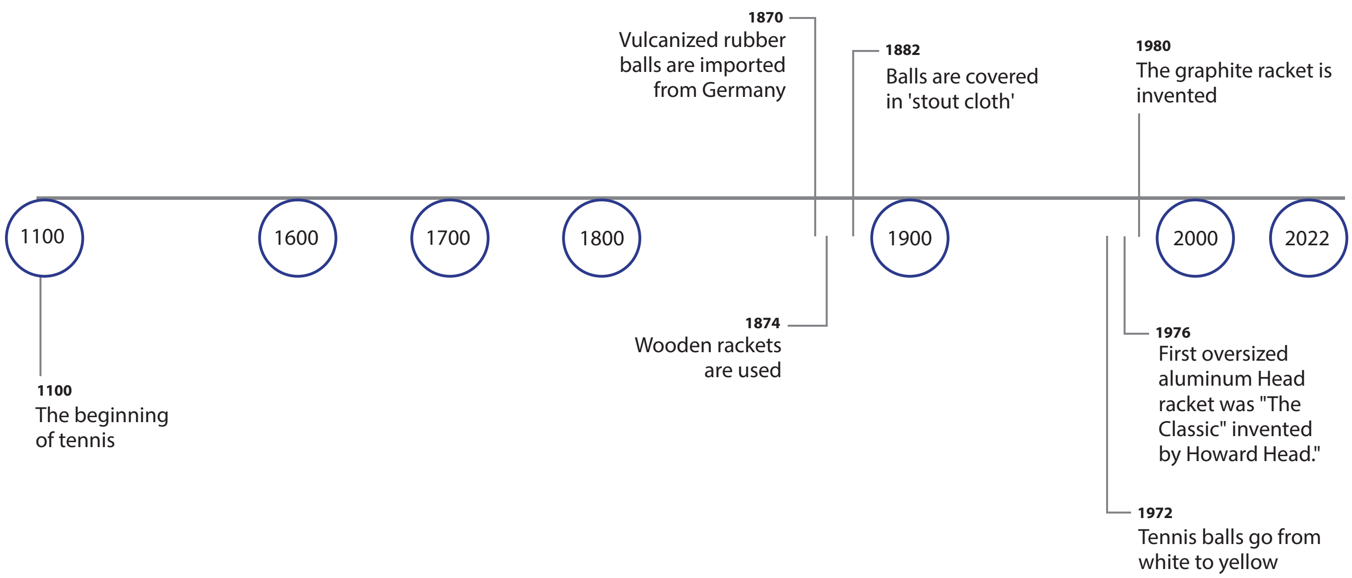
Name: ____

The Game Evolved

GRADES 3-5

Evaluate

Review the timeline below of the evolution of the tennis racket and ball.



Pros for using different rackets/balls as a tennis racket	Cons for using different rackets/balls as a tennis racket

STEM sports science • technology engineering • math • sports

Module
2.0

GRADES
3-5

Dimensions of the Court

Concept
Math: Drawing & Classifying Lines and Angles

Objective
Students will draw a scale model of a tennis court using a protractor. Students will identify important features of a tennis court and use that information to determine lines of symmetry.

Time
(2) 50-minute sessions

Standards

Common Core State Standards Connections

CCSS.MATH.CONTENT.4.G.A.1
Draw points, lines, line segments, rays, angles (right, acute, obtuse), perpendicular, and parallel lines. Identify these in two-dimensional figures.

CCSS.MATH.CONTENT.4.G.A.3
Recognize a line of symmetry for a two-dimensional figure as a line across the figure such that the figure can be folded along the line into matching parts. Identify line-symmetric figures and draw lines of symmetry.

CCSS.MATH.CONTENT.5.G.A
Graph points on the coordinate plane in one quadrant.

National Standards for K - 12 Physical Education Connections

Standard 2: The physically literate individual applies knowledge of concepts, principles, strategies and tactics related to movement and performance.

Standard 4: The physically literate individual exhibits responsible personal and social behavior that respects self and others.

Supplies Provided
Worksheets

Please email Info@STEMSports.com to access Worksheet Keys.

Materials Needed
Protractor and Colored Pencils

Sequence of Lesson

Have your students take this lesson's assessment prior to engaging by visiting:
www.stemsports.com/assessments
If you have limited digital capability, please email Info@STEMSports.com to access the Assessment & Key.

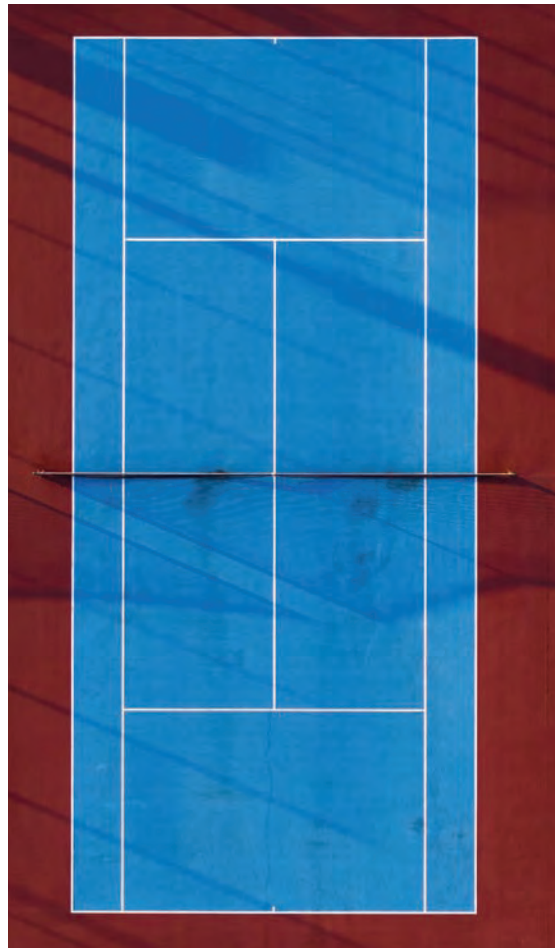
Engage: Ask students to think about the game of tennis: What shapes come to mind when you think about the court and/or equipment?

Explore: Show students a diagram of a tennis court. Ask them what they notice about the size and shape of the different parts of a court. How do they compare?

Explain: Define key mathematical terms: Point, Line (Segment), Right Angle, Parallel, Perpendicular, and Line of Symmetry.

Define key tennis terms : Baseline, Doubles Alley, Service Line, Center Service Line, Doubles Sideline, Singles Sideline.

These can be found in the STEM Sports® Glossary in the front of the manual and at STEMSports.com under Resources.



Elaborate: Model for students how to use a protractor to measure the length of the line, and the angle relationship. Using a protractor, have students follow the instructions on the worksheet provided to create a scale model of a tennis court.

Evaluate: Have students identify parallel and perpendicular lines, as well as lines of symmetry on the worksheet provided. Students can also use coloring utensils to identify these sets of lines.

Have your students retake this lesson's assessment to effectively evaluate their comprehension by visiting:
www.stemsports.com/assessments
If you have limited digital capability, please email Info@STEMSports.com to access the Assessment & Key.

Extend: Students could research the different courts used in the game of tennis, answering the question: What types of court surfaces are used in tennis?

STEM Jobs in Sports

- Sports Physical Therapist
- Athletic Clothing Designer
- Sports Ticket Sales
- Sports Complex Manager
- Tennis Instructor

Fun Fact

A player runs an average of three miles during a tennis match.

Name: ____________________

Dimensions of the Court

GRADES 3-5

Elaborate

Part 1: Using a protractor with a scale factor 1 m = 2/3 mm, draw a scale model of a tennis court.

1. At the top of your paper, draw a horizontal line that is 5.5 mm long. Label this your baseline.
2. At the right end of the baseline, create a 90 degree angle towards the bottom of your paper with the protractor, drawing a line that is 15.9 mm long. Label this your doubles sideline.
3. At the end of the doubles sideline, create a 90 degree angle towards the left side of your paper with the protractor, drawing a line that is 5.5 mm long. Label this your baseline.
4. At the end of the baseline, create a 90 degree angle towards the top of your paper with the protractor, drawing a line that is 15.9 mm long. Label this your doubles sideline.
5. Find the halfway or midpoint of your doubles sideline. From this point, draw a line that connects one side of the sideline to the other.
6. At the end of the baseline, measure 0.9 mm into the court and draw a line that connects one side of the baseline to the other. Label this your singles sideline.
7. Follow the same directions from Step 6, but on the other side of the baseline to draw the other singles sideline.
8. Starting at the intersection of the singles sideline and the net, measure 4.3 mm above the net. From this point, draw a line connecting one side of the singles sideline to the other. Label this the service line.
9. Follow the same directions from Step 8, but measure below the net. Label this the service line.
10. Find the halfway or midpoint of your service line, draw a line connecting the service line to the net; do this on both sides of the net. Label this your center service line.

Module 2.0

Name: ______________________________

Dimensions of the Court

GRADES 3-5

Evaluate

Part 2: Parallel, Perpendicular, and Lines of Symmetry

1. Using the scale model of your tennis court, use two different colored utensils to identify two sets of lines parallel to each other.

2. Using the scale model of your tennis court, use two different colored utensils to identify two sets of lines perpendicular to each other.

3. Using the scale model of your tennis court, use two different colored utensils to identify two lines of symmetry.

Module
3.0

GRADES
3-5

The Playing Surface

Concept
Science: Observation and Earth's Systems

Objective
Students will make observations on the different types of playing surfaces in tennis. Students will review and determine how inclement weather affects the playing surface/court. Students will discuss and record how they would adapt the playing surface and their play to remain safe yet effective.

Time
(2) 45-minute sessions

Standards

Next Generation Science Standards Connections

3-ESS3-1.
Make a claim about the merit of a design solution that reduces the impacts of a weather-related hazard.

4-ESS2-1.
Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation.

National Standards for K - 12 Physical Education Connections

Standard 1: The physically literate individual demonstrates competency in a variety of motor skills and movement patterns.

Standard 2: The physically literate individual applies knowledge of concepts, principles, strategies and tactics related to movement and performance.

Standard 4: The physically literate individual exhibits responsible personal and social behavior that respects self and others.

Supplies Provided
Worksheets

Please email Info@STEMSports.com to access Worksheet Keys.

Materials Needed
Outdoor Space

Sequence of Lesson

Have your students take this lesson's assessment prior to engaging by visiting:
www.stemsports.com/assessments
If you have limited digital capability, please email Info@STEMSports.com to access the Assessment & Key.

Engage: Have students go outside to roll and bounce the tennis ball on different surfaces, such as cement, dirt, and grass.

Explore: Based on their findings from *Engage*, have students use the worksheet to record the benefits and challenges of each surface.

Explain: Tell students the game of tennis is played on multiple surfaces. Review details and images below with students, explaining that the three most popular surfaces are concrete/hard courts, clay/dirt, and grass.

Concrete/Hard Surface: Hard Courts: Composed of layers of concrete or asphalt. The speed varies based on the amount of sand in the top layer. Generally faster than clay, yet slower than grass. The ball tends to bounce higher than a grass court, but not as high as a clay court.

Dirt/Clay Surface: Clay Courts: Composed of packed crushed brick. Balls on this surface move slower but bounce higher, resulting in longer rallies. There is also Green Clay used to make courts -- composed of crushed volcanic rock. These are slightly faster and harder than red clay courts.

Grass Surface: Grass Courts: The ball moves quickly and can have an unpredictable low bounce. Matches on grass courts are the fastest.

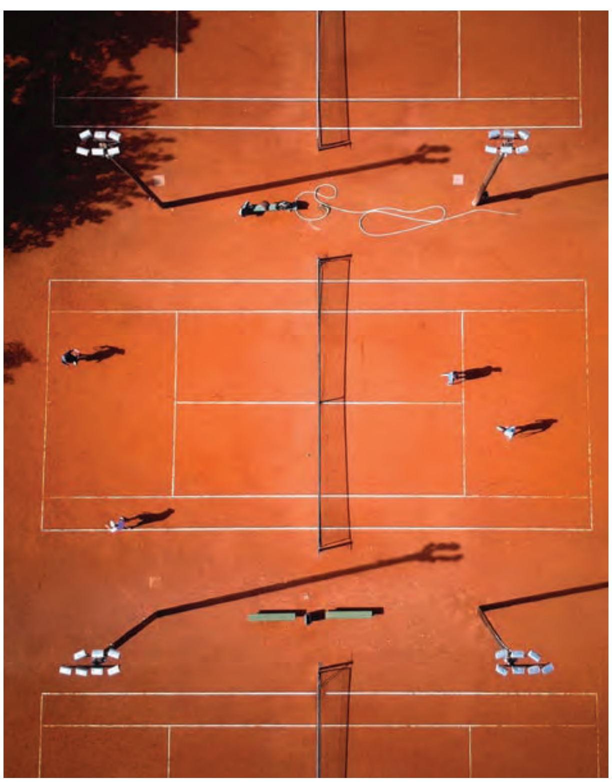
Elaborate: Explain to students that the playing surface can be significantly altered by the weather, having a significant impact on how player's approach and play the game. Reference the below examples:

Concrete/Hard Court: Rain and/or wet weather can cause water to settle on certain areas of the court, making it difficult for players to move quickly to the ball. In addition, water dampens and adds weight to the ball, decreasing speed and height when hit during play.

This surface can be a hazard for players if not properly maintained during inclement weather conditions, as a hard court that is slightly wet becomes slippery and extremely fast. However, hard court surfaces are easy to dry-out and maintain, unlike the clay and grass surfaces that erode/breakdown quickly due to wet weather conditions.

Clay/Dirt Court: As clay becomes wetter, the slicker it becomes, making it very difficult for players to move. Unlike a hard court, players can play on a slightly wet clay court.

Moreover, clay will stick to the ball, making it challenging for players to see and hit the ball with accuracy. This surface can be very hazardous if not properly maintained during inclement weather, as players can easily lose traction when running at a high rate of speed to the ball.



Grass Court: Wet areas on the court will decrease the quality of the ball bouncing, slowing the game down. This, coupled with a very slippery surface when wet, will create a slower pace of play.

Like a clay/dirt surface, this court can be very slippery and unforgiving when inclement weather hits. It is also challenging to maintain due to wear and tear of players going back and forth on the baseline and in the service areas. This can also make the surface uneven and a hazard to players.

Evaluate: Using the worksheet as a guide, have students discuss and record how they would adapt their play to remain safe yet effective.

- Which court/surface would you be most aggressive on and least aggressive on?

- Which types of conditions effect each surface/ court the most and how do you adapt the playing surfaces?

Have your students retake this lesson's assessment to effectively evaluate their comprehension by visiting:
www.stemsports.com/assessments

If you have limited digital capability, please email Info@STEMSports.com to access the Assessment & Key.

Extend: Students could research a tennis player or players to determine what court/surface they had the most success on and why.

STEM Jobs in Sports

- Tennis: Ball Boy/Girl
- Golf Course - Groundskeeper
- Tennis Court/Arena Architect
- Stadium/Arena: Quality Control Coordinator
- Event/Gameday Coordinator

Fun Fact

Rafael Nadal has found great success on clay courts. With 13 French Open Title Wins, he is called the "King of Clay."

Module 3.0

Name: ______________________________

The Playing Surface

GRADES 3-5

Explore

Surface	Rolling the Tennis Ball	Bouncing the Tennis Ball
Grass	**Benefits:** **Challenges:**	**Benefits:** **Challenges:**
Concrete (also known as a "hard surface")	**Benefits:** **Challenges:**	**Benefits:** **Challenges:**
Dirt	**Benefits:** **Challenges:**	**Benefits:** **Challenges:**

STEM sports
science • technology
engineering • math • sports

Name: ______________________________

The Playing Surface

GRADES 3-5

Evaluate

Surface	Adapt Play	Adapt Surface
Grass		
Clay		
Concrete/Hard Surface		

Module
4.0

GRADES
3-5

I'd Love to Keep Score

Concept
Math: Comparing Values and Expressions

Objective
Students will learn how to score the game of tennis through the popular theory of its correlation to an analog clock. Students will use this information to draw fraction diagrams that represent the score in a set, game, and match. Students will use these diagrams to compare different scores throughout a tennis match.

Time
(2) 60-minute sessions

Standards

Common Core State Standards Connections

CCSS.MATH.CONTENT.4.NF.A.2
Compare two fractions with different numerators and different denominators.

National Standards for K - 12 Physical Education Connections

Standard 1: The physically literate individual demonstrates competency in a variety of motor skills and movement patterns.

Standard 2: The physically literate individual applies knowledge of concepts, principles, strategies and tactics related to movement and performance.

Standard 4: The physically literate individual exhibits responsible personal and social behavior that respects self and others.

Supplies Provided
Worksheets and Handouts
Extend only: Tennis Rackets and Tennis Balls

Please email Info@STEMSports.com to access Worksheet Keys.

Materials Needed
Pencils
Extend only: Outdoor Space

Sequence of Lesson

Have your students take this lesson's assessment prior to engaging by visiting:
www.stemsports.com/assessments
If you have limited digital capability, please email Info@STEMSports.com to access the Assessment & Key.

Engage: Ask students to think of what a clock looks like at 3:00 PM. What are some features you would see? How does this compare to a clock that reads 6:00 PM or 9:00 AM?

Explore: Students will read about one theory on the history of scoring in tennis on pages 32-33. This article will describe the history behind scoring the game of tennis, including how it derived from reading an analog clock.

Explain: Using the worksheet, have students complete the following in the form of a fraction:

- If a player scores 0 points, draw a fraction model to represent the number of points needed to win the set.

- If a player scores 1 point, draw a fraction model to represent the number of points needed to win the set.

- If a player scores 2 points, draw a fraction model to represent the number of points needed to win the set.

- If a player scores 3 points, draw a fraction model to represent the number of points needed to win the set.

- If a player scores 4 points, draw a fraction model to represent the number of points needed to win the set.

Elaborate: Using the worksheet, have students complete the following in the form of a fraction:

- If a clock reads 12:15, draw a fraction model to represent the number of minutes needed to read 1:00.

- If a clock reads 12:30, draw a fraction model to represent the number of minutes needed to read 1:00.

- If a clock reads 12:40, draw a fraction model to represent the number of minutes needed to read 1:00.

- If a clock reads 12:45, draw a fraction model to represent the number of minutes needed to read 1:00.

Evaluate: What do you notice about your fraction models for the points scored in tennis compared to the time on the clock? Using the worksheet, have students complete the following using greater than, less than, or equal to symbols (> < =).

1. Tennis Point 1 ____ Clock 12:15
2. Tennis Point 2 ____ Clock 12:30
3. Tennis Point 3 ____ Clock 12:45
4. Why do you think the third tennis point is said to be 40 instead of 45?
5. Based on this pattern, what do you think is the final point in a tennis set?

Have your students retake this lesson's assessment to effectively evaluate their comprehension by visiting:
www.stemsports.com/assessments
If you have limited digital capability, please email Info@STEMSports.com to access the Assessment & Key.

Extend: Students could go outside and play a mock game of tennis to practice scoring, applying the content/language of scoring in the game.

STEM Jobs in Sports

- Sports Statistician
- Sports Broadcaster
- Software Engineer: Fitness Tracking Equipment
- Sports Agent
- Scoreboard Operator

Fun Fact

In some sports, scoring zero is referred to as a "goose egg" due to the shape of the number. The French word for egg is "l'oeuf", which sounds similar to "love" and why it is used to represent zero in tennis.

I'd Love to Keep Score!

Like other sports, the game of tennis has its own special way of scoring the game. Before a winner can be determined, three phases of the game must be played: a game, a set, and a match.

A **game** is played until a player can win by reaching 4 points. A point can be earned one of five ways:

- A player can not hit a ball, and the ball bounces twice.
- A **double fault** occurs where the server misses two back to back serves.
  An **Ace** occurs where the player's serve is unable to be returned.
- A ball is hit out of bounds.
- A ball is hit into the net.

Scoring in tennis is unlike any other sport. The first points are actually 15, 30, 40, and then the game winning point.

You might think the game of tennis would be scored as 0 points, 1 point, 2 points, 3 points, and 4 points. However, scoring in tennis is unlike any other sport. The first points are actually 15, 30, 40, and then the game winning point. There are many thoughts as to why tennis is scored this way, but one of the most popular ones is that the game of tennis, which dates back to 12th century France, 12th century France, was originally kept on the face of a clock. The hands of the clock would be moved from 0 minutes to 15 minutes, 30 minutes, 45 minutes, and 60 minutes to keep score.

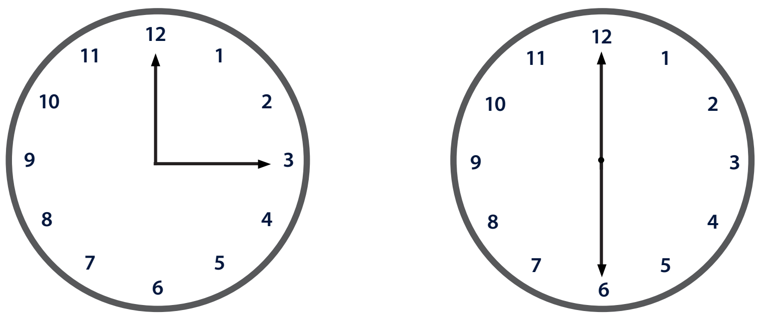
When announcing the score in tennis point zero is called **love**. There are also many thoughts of why the score of zero is referred to as "love", the most popular one is that it comes from the French word "l'oeuf" which means "egg". A "l'oeuf" resembles the number zero, which is why "love" is used in the game today. Point one is then called 15, point two is called 30, point three is called 40, and point four is called the game-winning point.

You might be wondering why point 3 is called 40 and not 45… Because if both

players make it to point 3 or 40, the score is called "deuce". In order to win, the player must win the next two points in a row. If a player can do this, the next two points would be called "advantage", then the game-winning point. If a player wins the first point, but loses the second point, the points would be called "advantage", then back to deuce. The 40-minute mark is used to represent point 3 in the event of a deuce, letting the 45-minute mark be used to represent the player who has the advantage in the match.

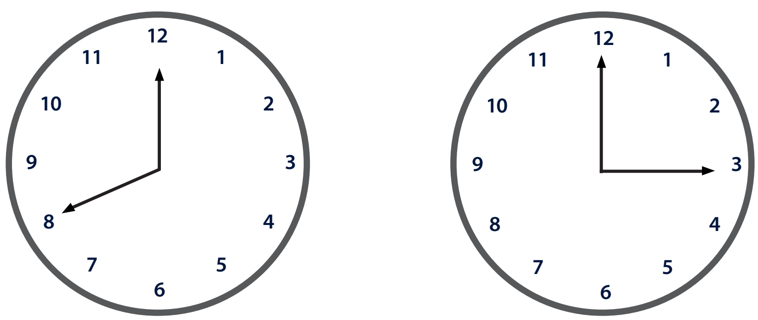
When a player reaches the **fourth** point, the game is over. The player must win **6** games in order to win the set. Likewise, the player must win by two points to win the set and they must win by two games to win the match. So if a game is at 6-5, a seventh game would have to be played to determine the set winner.

When a player reaches 2 sets won, the match is over!



Player A **Player B**

This model shows an example of Player A having 15/1 points and Player B having 30/2 points



Player A **Player B**

This model shows an example of a deuce, where Player A has the advantage

	Set 1	Set 2	Set 3	Match Winner
Player A	6	5	6	Player A
Player B	4	7	3	

Sources: https://www.sportingnews.com/us/tennis/news/tennis-scoring-explained-rules-system-points-terms/7uzp2evdhbd11obdd59p3p1cx

Module 4.0

Name: ______________________________

I'd Love To Keep Score

GRADES 3-5

Explain

Answer the following in the form of a fraction.

1. If a player scores 0 points, draw a fraction model to represent the number of points needed to win the set.

2. If a player scores 1 point, draw a fraction model to represent the number of points needed to win the set.

3. If a player scores 2 points, draw a fraction model to represent the number of points needed to win the set.

4. If a clock reads 12:45, draw a fraction model to represent the number of minutes needed to read 1:00.

5. If a player scores 4 points, draw a fraction model to represent the number of points needed to win the set.

Name: ____

I'd Love To Keep Score

GRADES 3-5

Explain

Answer the following in the form of a fraction.

1. If a clock reads 12:15, draw a fraction model to represent the number of minutes needed to read 1:00.

2. If a clock reads 12:30, draw a fraction model to represent the number of minutes needed to read 1:00.

3. If a clock reads 12:40, draw a fraction model to represent the number of minutes needed to read 1:00.

4. If a clock reads 12:45, draw a fraction model to represent the number of minutes needed to read 1:00.

Name: ____

I'd Love To Keep Score

GRADES 3-5

Evaluate

Use greater than, less than, or equal to symbols (> < =) to answer the following.

1. Tennis Point 1 _____ Clock 12:15

2. Tennis Point 2 _____ Clock 12:30

3. Tennis Point 3 _____ Clock 12:45

4. Why do you think the third tennis point is said to be 40 instead of 45?

5. Based on this pattern, what do you think is the final point in a tennis set?

STEM sports science • technology engineering • math • sports

Module 5.0

GRADES 3-5

May the Force Be With You!

Concept
Science: Balanced and Unbalanced Forces
Use of Technology

Objective
Students will design an experiment that collects evidence on gravity and pushing forces on two different tennis motions. Students will justify their explanation using key terms of balanced and unbalanced forces.

Time
(2) 45-minute sessions

Standards

Next Generation Science Standards Connections

3-PS2-1.
Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object.

National Standards for K - 12 Physical Education Connections

Standard 1: The physically literate individual demonstrates competency in a variety of motor skills and movement patterns.

Standard 2: The physically literate individual applies knowledge of concepts, principles, strategies and tactics related to movement and performance.

Standard 4: The physically literate individual exhibits responsible personal and social behavior that respects self and others.

Supplies Provided
Worksheets, Tennis Rackets, Tennis Balls, and Radar Gun

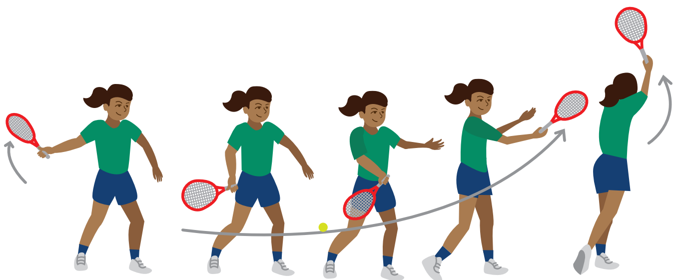
Please email Info@STEMSports.com to access Worksheet Keys.

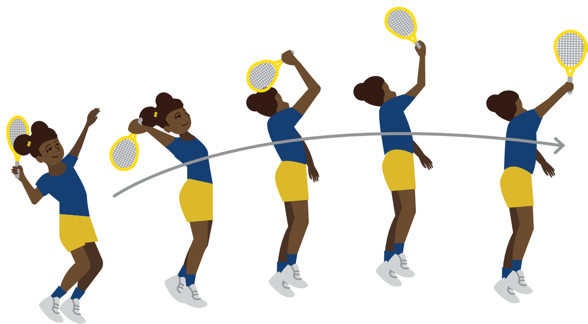
Materials Needed
Pencils and Smartphone or Tablet

Sequence of Lesson

Have your students take this lesson's assessment prior to engaging by visiting:
www.stemsports.com/assessments
If you have limited digital capability, please email Info@STEMSports.com to access the Assessment & Key.

Engage: Have students discuss with a partner why some hits are faster than others. Consider an overhand serve, forehand hit, and backhand hit. Have students draw a diagram of the technique for their fastest hit.





Explore: Have students reference the images above. Ask students to compare their drawing to these images by identifying similarities and differences. Then have students perform each type of hit – their idea of the fastest technique, the overhand serve, forehand hit, and backhand hit – to conduct an informal experiment. Write down informal data that includes observations and a rating system of slowest to fastest.

Explain: Define key vocabulary of Balanced and Unbalanced Forces, which can be found in the STEM Sports® Glossary in the front of the manual and at STEMSports.com under Resources. Explain the relationship between force, speed, and motion: the more motion in a hit = more force = more speed of a hit/serve.

Elaborate: In groups of 4, students will measure the time the ball starts its motion (the point at which it is hit) to the time it ends its motion (when it reaches the set distance). Each student will have a designated job.

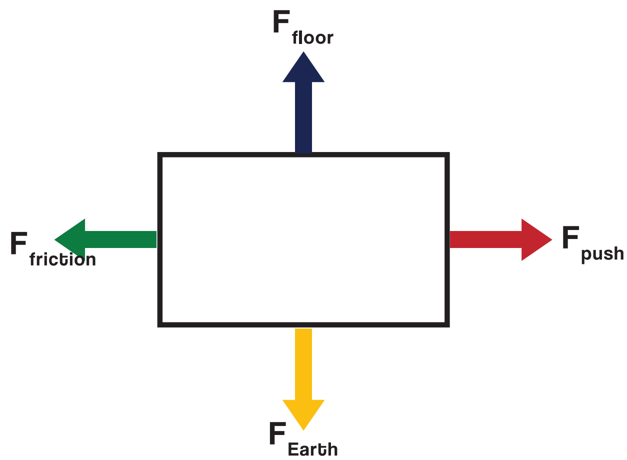
- One student will hit the ball using each hit type: overhand serve, forehand hit, and backhand hit.

- One student will record the speed of the ball using the radar gun.

- One student will measure the distance on the court that the ball travels. Example: service line to baseline, service box to baseline, etc.

- One student will use a smartphone or tablet to video record each hit. The slow motion technology will allow students to slow down the video and accurately see the acceleration of the hit.

Evaluate: Have students draw a force diagram of each hit, using a larger arrow to indicate a larger unbalanced force. Then have students use their data and diagrams to write a claim that explains how a larger unbalanced force will change the motion.



Have your students retake this lesson's assessment to effectively evaluate their comprehension by visiting:
www.stemsports.com/assessments
If you have limited digital capability, please email Info@STEMSports.com to access the Assessment & Key.

Extend: Students could design their own controlled experiment by throwing the tennis ball as their serve as the independent variable instead of the force generated by a tennis racket. What variable generated more force?

STEM Jobs in Sports

- Player Development, Assistant Coach/Hitting Coach
- Director of Junior Tennis
- USTA: Digital Product Manager
- Tennis Rackets: Impact Reporting - Graphic Design
- Summer Camp Tennis Counselor

Fun Fact

The average age of ball boys and girls serving in Wimbledon is 15 years old. Approximately 250 youth are selected to serve in the tournament each year.

Name: ____

May the Force Be With You!

GRADES 3-5

	Fastest (1) to slowest (4)	Observations
Overhand Serve		
Forehand Hit		
Backhand Hit		
Student Idea: ___________		

	Trial 1		Trial 2		Trial 3	
	Speed	Distance	Speed	Distance	Speed	Distance
Overhand Serve						
Forehand Hit						
Backhand Hit						
Student Idea: ___________						

Name: ____

May the Force Be With You!

GRADES 3-5

Evaluate

Use the below space to create your Force Diagrams.

How does a larger unbalanced force change motion? Answer using evidence from your experiment.

____

____

____

____

____

Module
6.0

GRADES
3-5

Stroke of Energy

Concept
Science: Energy

Objective
Students will experiment with the functionality and energy of a tennis ball by hitting it underhand and overhand. Students will explore and define the relationship between the velocity and energy of a tennis ball.

Time
(2) 50-minute sessions

Standards

Next Generation Science Standards Connections

4.PS3-1.
Use evidence to construct an explanation relating the speed of an object to the energy of that object.

National Standards for K - 12 Physical Education Connections

Standard 1: The physically literate individual demonstrates competency in a variety of motor skills and movement patterns.

Standard 4: The physically literate individual exhibits responsible personal and social behavior that respects self and others.

Supplies Provided
Worksheets, Tennis Balls, Tennis Rackets, Sweet Spot Ball-Striking System and Manual, Tape Measures, and Digital Stopwatches

Please email Info@STEMSports.com to access Worksheet Keys.

Materials Needed
Pencils, Calculator (recommended), and Outdoor Space

Sequence of Lesson

Have your students take this lesson's assessment prior to engaging by visiting:
www.stemsports.com/assessments
If you have limited digital capability, please email Info@STEMSports.com to access the Assessment & Key

Engage: Ask students how fast they can hit a tennis ball. Tell them the fastest serve recorded was 163.4 mph or 73 meters/second.

Explore: Set-up the Sweet Spot Ball-Striking System. Tell students that Physical literacy is an essential part of sports, and by using the Sweet Spot system and Ball-Striking Game Plan, students will develop the following:

1) Consistent ball-striking: It trains the eyes to stay on the ball in the last 3 feet until contact is made.

2) Student + Athlete: It improves overall mental focus and performance in the classroom and on the court.

Now, have students form a line and take turns striking the ball on the Sweet Spot system at least 10 times, or until you feel students are demonstrating consistent ball-striking.

Have students measure 10 meters. With a partner, have students hit the ball underhand and overhand and record how long it took the ball to travel that distance.

Teacher note: Distances can be altered based on age/ability.

Explain: Explain to students that the faster an object is moving, the more energy the object possesses. In tennis, in order to hit the ball fast, we have to use our entire body and not just our arms.

Elaborate: Have students repeat the process from *Explore*, but this time have them hit the ball overhand. Have students focus on the different parts of the body involved when hitting the ball overhand.

Evaluate: Using the worksheet, have students calculate the velocity of their underhand and overhand hits. Then have students explain why there is a difference in velocity from these hitting positions, with a focus on using different parts of the body when hitting the ball: more body movement = more velocity.

Have your students retake this lesson's assessment to effectively evaluate their comprehension by visiting:
www.stemsports.com/assessments
If you have limited digital capability, please email Info@STEMSports.com to access the Assessment & Key.

Extend: Students could go back outside and hit from the same distance as before, but instead of standing and hitting underhand/overhand, students could take a few steps before hitting. How did this change your velocity and why?

$$V = \frac{d}{t}$$

STEM Jobs in Sports

- Tennis Ball Manufacturer
- Tennis Pro: Youth Trainer & Coach
- Physics Teacher and Head Tennis Coach
- Pilates Instructor
- Tennis Equipment/Pro Shop Manager

Fun Fact

The fastest serve recorded was 163.4 mph or 73 meters/second.

Name: ____

Stroke of Energy

GRADES 3-5

Explore

Record the times in the table below.

Underhand Hit   Distance: ____________________

	Hit 1	Hit 2	Hit 3	Hit 4	Hit 5
Partner A					
Partner B					

Overhand Hit   Distance: ____________________

	Hit 1	Hit 2	Hit 3	Hit 4	Hit 5
Partner A					
Partner B					

Module 6.0

Name: ____

Stroke of Energy

GRADES 3-5

Evaluate

Calculate Velocity

Underhand Hit Distance: ____________________

	Hit 1	Hit 2	Hit 3	Hit 4	Hit 5
Partner A					
Partner B					

Overhand Hit Distance: ____________________

	Hit 1	Hit 2	Hit 3	Hit 4	Hit 5
Partner A					
Partner B					

Which hit were you able to hit with more velocity and why?

____

____

STEM sports
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Module
7.0

GRADES
3-5

Let's Serve

Concept
Math: Decimal Notation for Fractions
Use of Technology

Objective
Students will learn the rules and strategies of serving in tennis. Students will use technology to find the speed of their serve. Students will analyze the speed and accuracy of their first serve to compare to their second serve.

Time
(2) 50-minute sessions

Standards

Common Core State Standards Connections

CCSS.MATH.CONTENT.4.NF.C.5
Express a fraction with denominator 10 as an equivalent fraction with a denominator of 100.

CCSS.MATH.CONTENT.4.NF.C.6.
Use decimal notation for fractions with denominators 10 (tenths) or 100 (hundredths), and locate these decimals on a number line.

CCSS.MATH.CONTENT.5.NF.B.7
Apply and extend previous understandings of division to divide unit fractions by whole numbers and whole numbers by unit fractions.

National Standards for K - 12 Physical Education Connections

Standard 1: The physically literate individual demonstrates competency in a variety of motor skills and movement patterns.

Standard 2: The physically literate individual applies knowledge of concepts, principles, strategies and tactics related to movement and performance.

Standard 4: The physically literate individual exhibits responsible personal and social behavior that respects self and others.

Supplies Provided
Worksheets, Tennis Rackets, Tennis Balls, and Radar Gun

Please email Info@STEMSports.com to access Worksheet Keys.

Materials Needed
Pencils and Tennis Court

Video
The Rule of Tennis Explained:
stemsports.com/resources/resources-tennis/

Sequence of Lesson

Have your students take this lesson's assessment prior to engaging by visiting:
www.stemsports.com/assessments
If you have limited digital capability, please email Info@STEMSports.com to access the Assessment & Key.

Engage: Ask students: If you get two attempts to serve the ball in bounds, how confident are you that you could do this? What if you only get one try?

Explore: Have students go outside to the tennis court. Ask students to identify the parts of the court relevant when serving, such as: Service Box, Service Line, Center Service Line, and Sideline.

Explain: Show students the video on the rules of tennis, which can be found at STEMSports.com, then click on STEM Tennis under Resources. Pinpoint and focus on the rules and positioning of serving with students. Tell them that depending on what side of the court they choose to serve, will determine what service box they will hit the ball to. Reference back to the video and explain to students what serve would be considered In, Out, or Let.

Elaborate: Have students hit 10 serves and measure the speed of each serve using a radar gun. If a student does not hit their first serve in, they must serve their second serve. Use the worksheet as a guide.

Teacher note: Service line distance can be altered based on age/ability.

Evaluate: Have students answer the questions on the worksheet.

Have your students retake this lesson's assessment to effectively evaluate their comprehension by visiting:
www.stemsports.com/assessments
If you have limited digital capability, please email Info@STEMSports.com to access the Assessment & Key.

Extend: Remind students how to divide a whole number by a fraction. Students could discuss and/or answer the questions on the worksheet.

STEM Jobs in Sports

- Tennis Scout
- Scoreboard Operator
- Middle School: Math Teacher and Tennis Coach
- Team Videographer
- Tennis - Statistical Analyst

Fun Fact

Arthur Ashe was the first African American to win the US Open in 1968.

Name: ____________________

Let's Serve

GRADES 3-5

First Serve			Second Serve (only needed if first serve is not inbounds)	
Serve Number	Speed	Result In - Out - Let	Speed	Result In - Out - Let
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

Module 7.0

Name: ____________________

Let's Serve

GRADES 3-5

Evaluate

1. Express the number of times you hit your first serve inbound as a fraction and decimal.

2. Based on the fraction above, write a fraction to represent 100 total serves.

3. Express the number of times you hit your second serve inbound as a fraction and decimal.

4. Based on the fraction above, write a fraction to represent 100 total serves.

5. How do your fractions from your first serve and second serve compare?

6. How does the speed from your first serve and second serve compare?

Name: ____

Let's Serve

GRADES 3-5

Extend

1. If a student was able to hit ¼ of their first serves inbound out of 20 serves, how many times would they serve it inbounds? How many times would they serve it out of bounds?

2. If a student was able to hit ⅔ of their first serves inbound out of 30 serves, how many times would they serve it inbounds? How many times would they serve it out of bounds?

Module
8.0

GRADES
3-5

Advancements in Tennis

Concept
Engineering: Criteria and Constraints of Technology
Use of Technology

Objective
Students will examine the use of instant replay in tennis. Students will evaluate instant replay technology by brainstorming and developing a list of criteria and constraints. Students will write a letter based on their findings to determine if the needs of all stakeholders are being met.

Time
(2-3) 50-minute sessions

Standards.

Next Generation Science Standards Connections

3-5-ETS1-2.
Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

3-5-ETS1-3.
Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

National Standards for K - 12 Physical Education Connections

Standard 1: The physically literate individual applies knowledge of concepts, principles, strategies and tactics related to movement and performance.

Standard 2: The physically literate individual applies knowledge of concepts, principles, strategies and tactics related to movement and performance.

Standard 4: The physically literate individual exhibits responsible personal and social behavior that respects self and others.

Supplies Provided
Worksheets, Tennis Balls, and Tennis Rackets

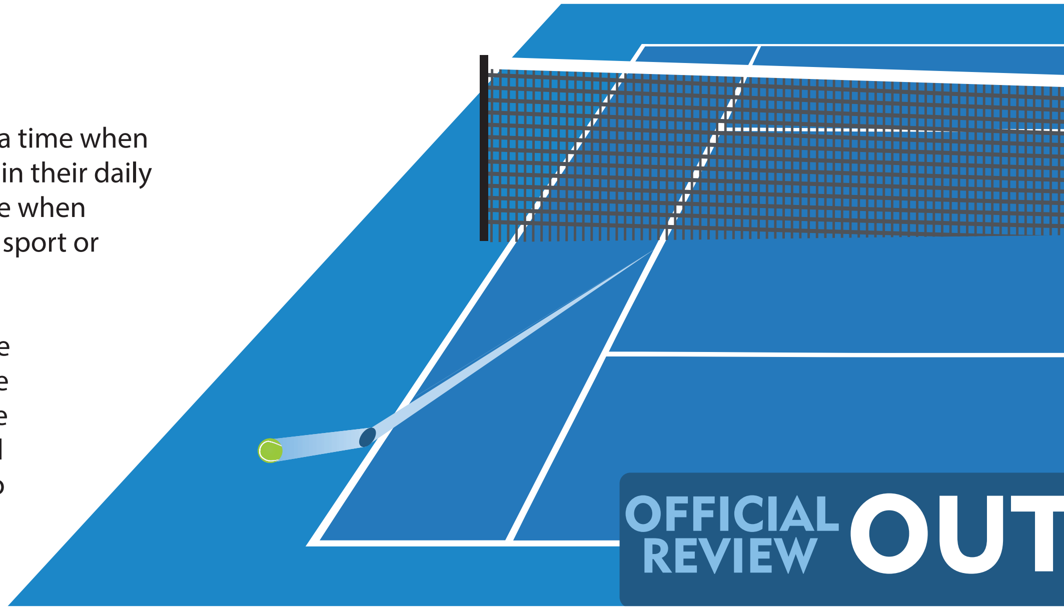
Please email Info@STEMSports.com to access Worksheet Keys.

Materials Needed
Pencils and Smartphone or Tablet

Video:
Video Replay Option #3: stemsports.com/resources/resources-tennis/

Sequence of Lesson

Have your students take this lesson's assessment prior to engaging by visiting:
www.stemsports.com/assessments
If you have limited digital capability, please email Info@STEMSports.com to access the Assessment & Key.



Engage: Ask students to think of a time when they wish they had "instant replay" in their daily lives. Ask students to think of a time when instant replay could be helpful in a sport or sports; specifically, tennis.

Explore: Ask students to go to the tennis courts. In groups of 3-4, have students perform and rotate for the following practice: one student will hit the ball over the net, one or two students will determine if the ball is in or out and record results on the worksheet, and one student will video record each hit using a smartphone or tablet to watch the results frame-by-frame.

Ask students to discuss their results of each shot. Did all team members agree their hits were in or out? What were some pro's and con's of using technology during this process?

Teacher note: Adjust hitting distance based on age/ability.

Explain: Tell students that tennis uses a form of technology called "Hawk-Eye instant review" and that it is used when a player challenges the call of the line judge or chair umpire. Explain to them that Hawk-Eye technology has both a positive and negative impact on the game.

Using the worksheet as a guide, have students continue brainstorming with their groups from *Explore*, writing down criteria and constraints using technology in tennis, such as Hawk-Eye. Tell students to consider the players, officials, and spectators when creating this list.

Elaborate: Have students watch the video on instant replay, which can be found at STEMSports.com, then click on STEM Tennis under Resources. After watching the video, have students add to their lists of criteria and constraints of using replay technology.

Evaluate: After students have brainstormed, have them write a letter to the USTA (United States Tennis Association). The letter should take a stance for supporting or opposing the use of instant replay in tennis. The letter should also include specific changes and improvements to benefit all stakeholders: players, officials, and spectators.

Example Prompts: Does using Hawk-eye technology make the game of tennis more fair? How does or does not using Hawkeye meet the needs of all stakeholders? Does the game of tennis need line judges and chair officials?

Have your students retake this lesson's assessment to effectively evaluate their comprehension by visiting:
www.stemsports.com/assessments
If you have limited digital capability, please email Info@STEMSports.com to access the Assessment & Key.

Extend: Students could present their letter to the class, which could include a small group reading the letter, a gallery walk of the letters, or a small group Q & A.

STEM Jobs in Sports

- Director of Broadcast Technology
- Tennis Developer (IT) - Data and Development
- Internet - Sports Producer
- Team Photographer
- Tennis Commissioner

Fun Fact

Did you know that if the ball hits a player's body or any part of their clothing before it lands, it is their opponent's point (even if it would have gone out)?

Module 8.0

Name: ____

Advancements in Tennis

GRADES 3-5

Explore

X = In   O = Out

	Hit 1	Hit 2	Hit 3	Hit 4	Hit 5	Hit 6	Hit 7	Hit 8
Line Judge 1								
Line Judge 2								
Video Judge								

Explain/Elaborate

Criteria	Constraints
______________________	______________________
______________________	______________________
______________________	______________________
______________________	______________________
______________________	______________________

STEM sports science • technology engineering • math • sports

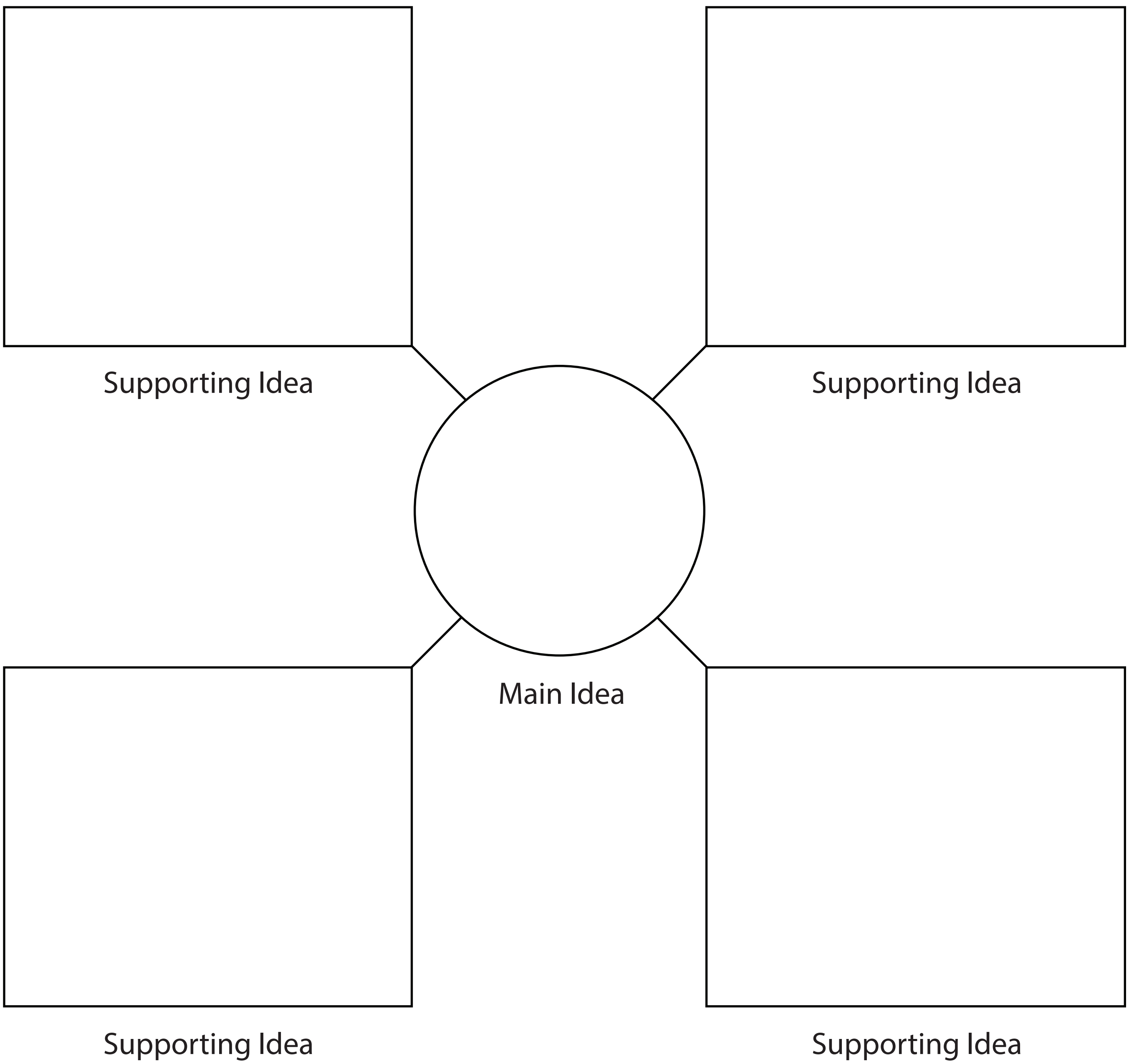
Name: ____

Advancements in Tennis

GRADES 3-5

Evaluate

Use the below graphic organizer to create an outline of your letter to the USTA (United States Tennis Association).



Name: ______________________________

Advancements in Tennis

GRADES 3-5

Evaluate

Have students write a letter to the USTA (United States Tennis Association). The letter should take a stance for supporting or opposing the use of instant replay in tennis. The letter should include specific changes and improvements to benefit all stakeholders involved: players, officials, and spectators.

Module 1.0

GRADES 6-8

The Game Evolved

Concept
Science: Observation and Interaction of Matter

Objective
Students will answer text-dependent questions about the evolution of the equipment used in tennis. Students will analyze the pros and cons of the design of tennis equipment over time.

Time
(1) 60-minute block

Standards

Next Generation Science Standards Connections

MS-PS1-3. Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.

National Standards for K - 12 Physical Education Connections

Standard 1: The physically literate individual demonstrates competency in a variety of motor skills and movement patterns.

Standard 4: The physically literate individual exhibits responsible personal and social behavior that respects self and others.

Supplies Provided
Worksheets, Tennis Rackets, and Tennis Balls

Please email Info@STEMSports.com to access Worksheet Keys.

Materials Needed
Pencils, various Sport Balls: Softball, Baseball, and Golf Ball; various items to hit the ball: Badminton Racket, Ping Pong Paddle, Baseball / Softball Bat.

Videos
How they make Tennis rackets:
stemsports.com/resources/resources-tennis/

Sequence of Lesson

Have your students take this lesson's assessment prior to engaging by visiting:
www.stemsports.com/assessments
If you have limited digital capability, please email Info@STEMSports.com to access the Assessment & Key.

Engage: Ask students to observe a tennis racket and tennis ball. Have them discuss the traits of the racket and ball. How are these traits unique to the sport of tennis?

Explore: Have students read the article on pages 57-58 of "The Game Evolved." After reading the article, have students watch the video on how they make tennis rackets, which can be found at STEMSports.com, then click on STEM Tennis under Resources.

Explain: Review key terms: Tennis Racket, Paddle, and Graphite, which can be found in the STEM Sports® Glossary in the front of the manual and at STEMSports.com under Resources. Explain how the availability of materials has played a role in the evolution of the tennis racket and ball. Explain how engineers have to change their design based on the materials available to improve the overall design of the equipment.

Elaborate: Using the worksheet, answer the questions from the "The Game Evolved" article. Then have students summarize their learning by creating a timeline of the evolution of the tennis racket and ball. Discuss why some of these changes to the ball and racket used were necessary to the improvement of the overall game. For instance, why don't we use a lacrosse ball on a tennis racket? Why don't we use a pickleball paddle on a golf ball? Using the table provided, have students experiment by mixing different racket and ball options.

Teacher note:
Racket: potential options - tennis racket, hand, bottom of shoe, paddle
Ball: potential options - tennis ball, wiffle ball, golf ball, lacrosse ball

Evaluate: Have students record their data from the *Elaborate* activity on the table provided. Have students reflect and evaluate the pro's and con's of each different combination.

Have your students retake this lesson's assessment to effectively evaluate their comprehension by visiting:
www.stemsports.com/assessments
If you have limited digital capability, please email Info@STEMSports.com to access the Assessment & Key.

Extend: Students could engineer their own racket and compared to a standard racket:

- Would you make it longer/shorter and why? What advantages/disadvantages are created.
- Would you make it heavier/lighter and why? What advantages/disadvantages are created.

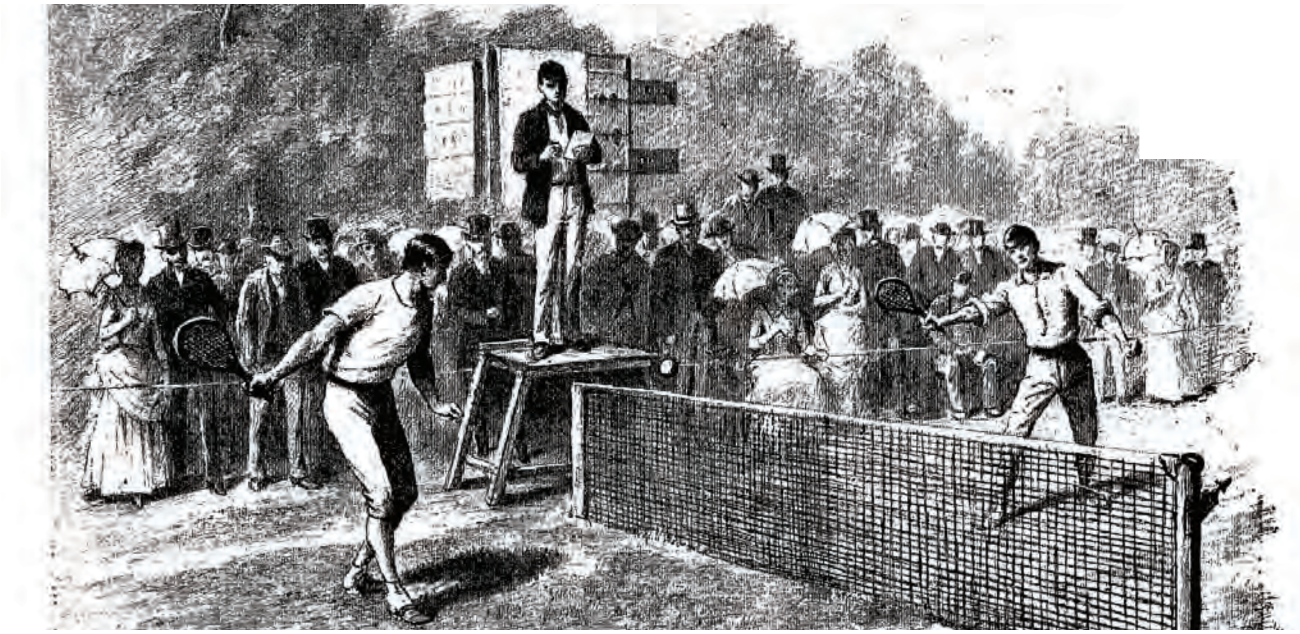
STEM Jobs in Sports

- Tennis Chair Umpire
- Tennis Racket Engineer
- Sports Equipment Store Manager
- Physical Education Teacher
- Sports Equipment Coordinator

Fun Fact

The game of Tennis comes from the French term "tenez" which means "take this". Players would play the game, and shout "tenez" throughout!

The Game Evolved



The game of tennis and its equipment has changed significantly since its introduction in France during the 12th century. In the early days of the game, players would play on a hard oval surface such as wood or stone and would hit a wooden ball back and forth with their bare hand over a rope stretched from one side to the other; however this style of game caused too many injuries. As a result, players began using leather gloves and leather balls toward the end of this century.

In the 13th century, the glove design evolved and players began using teardrop shaped wooden paddles with no webbing. These paddles were heavy, not flexible, and proved to be an insufficient design.

In the 14th century, the design of the paddle drastically changed to the racket we see today. The design was a long wooden handle with a teardrop wooden frame, connected with strings. The addition of the strings increased the distance and bounce of the ball, improving the overall game play. In addition to the racket improvement, a new type of cork ball was also introduced. This ball was tightly wound with fabric and covered in cloth.

The evolution of the equipment in the game of tennis remained constant, until 1850 when Charles Goodyear (Goodyear Tires) introduced a revolutionary process that made natural rubber more durable, allowing the ball to be bouncier and used on all types of playing surfaces. Twenty years later, Walter C. Wingfield took Goodyear's solid rubber ball design and found that if the rubber ball was hollow and filled with air, the bounce and quality of the ball significantly improved. Two years later, Wingfield improved his design one more time by covering his rubber ball in a cloth. This design is still what we use today.

Popular tennis companies, like Penn, took these ideas and continued to improve the performance of tennis balls over the next few decades. In 1970, Penn released their "play-rated" balls. These are unique tennis balls designed to maximize the play on different court surfaces and high altitude areas. In 2001, they released a tennis ball with SMART

OPTIK felt that increases visibility. In 2010, Penn introduced multiple 10 and under tennis balls specifically designed to encourage more kids to play tennis; these balls were lower pressurized balls that allowed for longer rallies, making tennis more fun.

By 2011, Penn introduced their longest lasting tennis ball featuring Encore Technology, creating a ball lasting 22% longer than the previous one. With several innovations in ball design, Winfield decided it was time to look at the other piece of equipment, the racket. The original paddle design from earlier centuries heavily inspired his very first tennis racket made in 1874; this racket was a large oval, made of solid wood and connected together by gut. The design of Wingfield's racket was used consistently over the next hundred years. By 1947, new laminating technology allowed thinner layers of wood to bond together, which increased the overall performance and durability of Wingfield's design. It is no surprise Wingfield is considered one of the "Founding Fathers" of tennis with many contributions to the game's equipment, as he provided many of the concepts, rules, and designs of the game. The most significant advancement in the engineering design of the racket occurred in 1967, when Wilson released the

Tennis Racket and Ball circa early 1900s

Tennis Racket and Ball circa early 2000s

very first steel racket, T2000. The head of the Head Classic Racket was twice the size of the models that came before it with 67 square inches of hitting space. Although significantly bigger, it was still much lighter and easier to swing than wooden rackets of the past.

Wilson's design inspired other engineers to try and improve the metals used in the racket. After years of testing and redesign, a breakthrough occurred in 1976. Graphite was found to be the most effective metal: it is lightweight and strong. Since this breakthrough to graphite, rackets haven't changed too much. Rackets today are simply a combination of different alloys, ceramics, and fiberglass to meet the needs of the individual player.

The equipment and game of tennis has remained consistent now for many years. However, current-day technology used throughout the world is changing faster than ever before. What will be the next big change to the game of tennis? And will these changes improve the game as players, officials, and spectators see it?

Sources: https://medium.com/lantern-theater-company-searchlight/the-evolution-of-tennis-2b1b4b99e93f

https://www.thoughtco.com/who-invented-tennis-1991673

Name: ____________________ Class: __________

The Game Evolved

GRADES 6-8

Elaborate

1. The paddle design in the 14th century resembles the racket we use today. What were the strengths of this design? What were the weaknesses of this design?

2. What changes were made to the tennis ball over time?

3. What do you believe was Wingfield's most significant contribution to the game of tennis?

4. Why is the introduction of graphite considered one of the biggest breakthroughs in the equipment of tennis?

5. What do you think will be the next big change to the game of tennis?

Module 1.0

Name: ______________________________ Class: ____________

The Game Evolved

GRADES 6-8

Elaborate

Complete the timeline below of the evolution of the tennis racket and ball.

1000	1300	1500	1700	1900
1200	1400	1600	1800	2000

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Name: ______________________________ Class: __________

The Game Evolved

GRADES 6-8

Evaluate

Describe how each ball would behave using some of or all of the options provided. Think about the distances and bounce-ability of each racket and ball type.

Options	Tennis Ball	Golf Ball	Softball	Baseball
Tennis Racket				
Bottom of Your Shoe				
Ping Pong Paddle				
Baseball/Softball Bat				
Badminton Racket				

Module 1.0

Name: ______________________ Class: __________

The Game Evolved

GRADES 6-8

Evaluate

Using the data collected from your table in *Evaluate*, create a list of pros and cons for the different combinations used.

Pros for using different rackets/balls as a tennis racket.	Cons for using different rackets/balls as a tennis racket.

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Dimensions of the Court

Concept
Math: Coordinate Plane System and/or Pythagorean Theorem

Objective
Students will draw a scale model of a tennis court on a coordinate plane. Students will use a coordinate plane system to determine the distance a player has to travel to hit the ball back to their opponent.

Time
(2) 50-minute blocks

Standards

Common Core State Standards Connections

CCSS.MATH.CONTENT.6.NS.C.8
Solve real-world and mathematical problems by graphing points in all four quadrants of the coordinate plane. Including the use of coordinates and absolute value to find distances between points with the same first coordinate or the same second coordinate.

CCSS.MATH.CONTENT.8.G.B.8
Apply the Pythagorean Theorem to find the distance between two points in a coordinate system.

National Standards for K - 12 Physical Education Connections

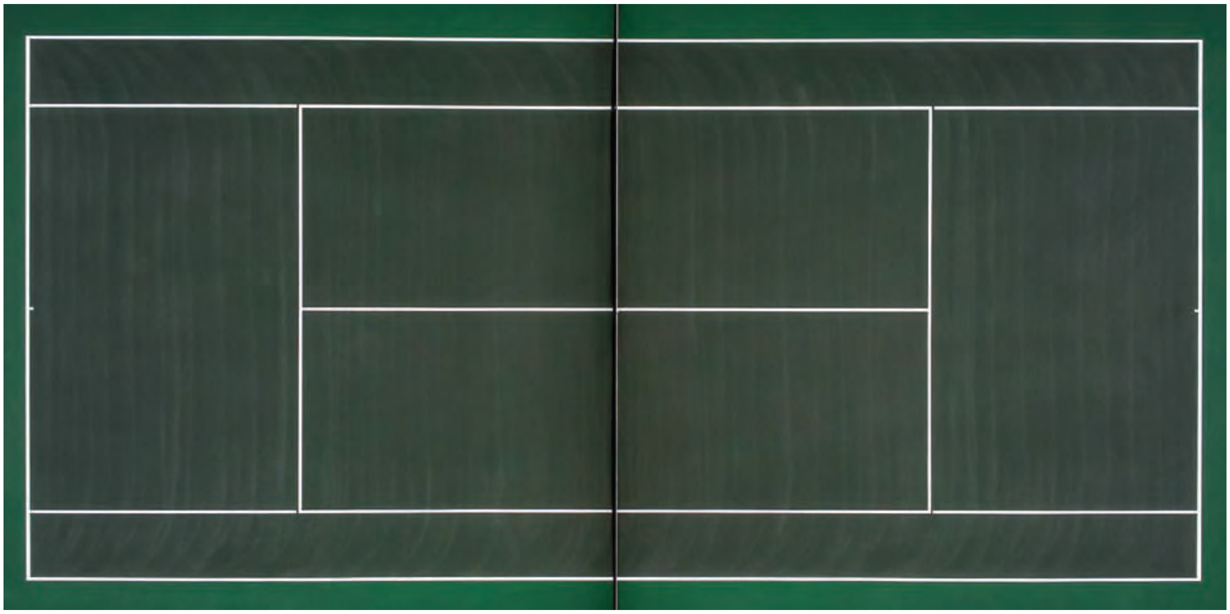
Standard 1: The physically literate individual demonstrates competency in a variety of motor skills and movement patterns.

Standard 4: The physically literate individual exhibits responsible personal and social behavior that respects self and others.

Supplies Provided
Worksheets and Ball of String (if outside court is not available)

Please email Info@STEMSports.com to access Worksheet Keys.

Materials Needed
Pencils, Notebook or Blank Paper
Extend only: Outdoor Space



Sequence of Lesson

Have your students take this lesson's assessment prior to engaging by visiting:
www.stemsports.com/assessments
If you have limited digital capability, please email Info@STEMSports.com to access the Assessment & Key.

Engage: Using their notebooks or blank paper, ask students to draw a tennis court, labeling as many court features as possible. Then have students brainstorm where a player should stand to receive a serve: Where should they stand to receive a hit? Where should they not stand to receive a hit?

Explore: Review with students the features and dimensions of a tennis court. Using the worksheet, have students plot court features on the coordinate plane system.

Explain: Define key mathematical terms: Coordinate Plane System and Pythagorean Theorem, which can be found in the STEM Sports® Glossary in the front of the manual and at STEMSports.com under Resources. Model for students how to calculate the distance a player has to travel to hit the ball back to their opponent.

Elaborate: Using the worksheet, have students calculate the remaining distance a player must travel to hit the ball back to their opponent.

Evaluate: Using the worksheet, have students create their own question, modeling a point in tennis similar to those calculated in *Elaborate.*

Have your students retake this lesson's assessment to effectively evaluate their comprehension by visiting:
www.stemsports.com/assessments
If you have limited digital capability, please email Info@STEMSports.com to access the Assessment & Key.

Extend: Students could go outside to a life-sized tennis court to visualize the distances players would have to travel to hit each ball back to their opponent. If a tennis court is not available, students could use string to create an outline of a tennis court.

STEM Jobs in Sports

- Engineer Technician - Stadium/Arena
- Director of Facilities
- Youth Sports Director
- High School: Geometry Teacher and Head Tennis Coach
- Stadium/Arena Architect

Fun Fact

The longest tennis match took 11 hours and 5 minutes to complete.

Name: ______________________ Class: __________

Dimensions of the Court

GRADES 6-8

Explore

Use the coordinate plane system to answer/plot the below questions/coordinates.

Name: ______________________ **Class:** __________

Dimensions of the Court

GRADES 6-8

Explore

1. Plot the points (-13, 9) and (-13, -9). Connect the points to draw one of the baselines.

2. Plot the points (13, 9) and (13, -9). Connect the points to draw the other baseline.

3. Connect the points (-13, 9) and (13, 9) to draw the sideline.

4. Connect the points (-13, -9) and (13, -9) to draw the sideline

5. Plot the points (-13, 10) and (13, 10). Draw a rectangle connecting (-13, 9), (-13,10), (13,10), and (13, 9) to draw the additional sideline needed for Doubles Tennis.

6. Plot the points (-13, -10) and (13, -10). Draw a rectangle connecting (-13, -9), (-13, -10), (13, -10), and (13, -9) to draw the additional sideline needed for Doubles Tennis.

7. Plot the points (0, -10) and (0,10). Connect the points to draw the net.

8. Plot the points (-7, 0), (-7, 9), (0, 9), and (0, 0). Connect the points to draw a rectangular service box.

9. Plot the points (-7, 0), (-7, -9), (0, -9), and (0, 0). Connect the points to draw a rectangular service box.

10. Plot the points (7, 0), (7, 9), (0, 9), and (0, 0). Connect the points to draw a rectangular service box.

11. Plot the points (7, 0), (7, -9), (0, -9), and (0, 0). Connect the points to draw a rectangular service box.

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Module 2.0

Name: ____________________ Class: __________

Dimensions of the Court

GRADES 6-8

Elaborate

7th Grade Standard

Determine the distance the player and ball travels.

1. Player A hits the ball from (-15, -6) to (-15, 8). How far did the ball travel?

2. Player C moves from (14, 7) to (14, -3) to make a play on the ball. How far did player C move?

3. In a doubles match, Player A is standing at (-14, -4) and Player B is standing at (-7, -4). If the ball is hit to (0, -4), which player is the closest to hit the ball?

Name: ______________________________ **Class:** __________

Dimensions of the Court

GRADES 6-8

Elaborate

8th Grade Standard

Using the Pythagorean Theorem, determine the distance the player and ball travels.

1. Player A serves from (-14, -8) to Player C at (16, 6). How far did the ball travel?

2. Player C returns the ball from (16, 6) to (-15, 2). How far did the ball travel?

3. Player A scores a point by returning the ball from (-15, 2) to (5, -6). How far did the ball travel?

Evaluate

Create your own question, modeling a point in tennis similar to those calculated in *Elaborate*.

____

____

____

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The Playing Surfaces

Concept
Engineering Design Solutions

Objective
Students will observe and test various surfaces to identify benefits and challenges. Students will examine the multiple surfaces the game is played on. Students will evaluate and apply solutions to how a player needs to adapt to the criteria and constraints of each surface/court.

Time
(2) 50-minute blocks

Standards

Next Generation Science Standards Connections

MS-ETS-1.1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

MS-ETS-1.2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

MS-ETS-1.3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

MS-ETS-1.4.
Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

National Standards for K - 12 Physical Education Connections

Standard 1: The physically literate individual demonstrates competency in a variety of motor skills and movement patterns.

Standard 2: The physically literate individual applies knowledge of concepts, principles, strategies and tactics related to movement and performance.

Supplies Provided
Worksheets and Tennis Balls

Please email Info@STEMSports.com to access Worksheet Keys.

Materials Needed
Outdoor Space

Videos
Surface and courts videos:
stemsports.com/resources/resources-tennis/

Sequence of Lesson

Have your students take this lesson's assessment prior to engaging by visiting:
www.stemsports.com/assessments
If you have limited digital capability, please email Info@STEMSports.com to access the Assessment & Key.

Engage: Have students go outside to roll and bounce the tennis ball on different surfaces, such as grass, cement and dirt.

Explore: Using the worksheet as a guide, have students analyze the benefits and challenges of each surface.

Explain: Tell students the game of tennis is played on multiple surfaces. Review with students the three most popular surfaces: grass, clay, and concrete/hard courts.

Grass Courts: The ball moves quickly and can have an unpredictable bounce. Matches on grass courts are the fastest.

Clay Courts: Composed of packed crushed brick. Balls on this surface move slower but bounce higher, resulting in longer rallies. There is also Green Clay used to make courts -- composed of crushed volcanic rock. These are slightly faster and harder than red clay courts.

Hard Courts: Composed of layers of concrete or asphalt. The speed varies based on the amount of sand in the top layer. Generally faster than clay, yet slower than grass. The ball tends to bounce higher than a grass court, but not as high as a clay court

Play the following videos for students for a more in-depth look at the surfaces tennis is played on, which can be found at STEMSports.com, then click on STEM Tennis under Resources.

"Video Explaining Courts"

"Video - Different Courts Effect on Speed/Bounce of Ball"

Using the worksheet as a guide, have students provide Criteria and Constraints of each playing surface.

Elaborate: Tell students that players have to adapt to the various criteria and constraints of the courts. How would a player have to adapt their game to be successful on each playing surface? Reference the below examples.

- **Grass Courts**: Better for players with faster technique and speed.
  Examples: Roger Federer and Serena Williams
- **Clay Courts**: Better for players with endurance.
  Example: Rafael Nadal and Chris Evert
- **Hard Courts**: Favors the all around player.
  Example: Novak Djokovic and Lindsay Davenport

Clay Court

Grass Court

Hard Court

Evaluate: Using the worksheet provided, have students discuss and record how a player would need to adapt to the criteria and constraints of the court.

Have your students retake this lesson's assessment to effectively evaluate their comprehension by visiting:
www.stemsports.com/assessments
If you have limited digital capability, please email Info@STEMSports.com to access the Assessment & Key.

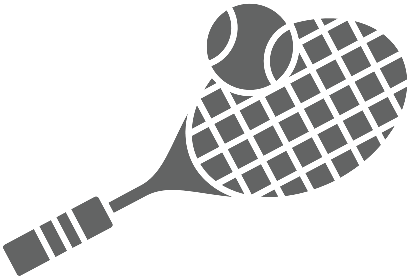
Extend: Players have to adapt to the type of court, as well as the weather conditions that affect the court. Students could research the following popular and widely used courts:

- Grass Court: Wimbledon - England
- Red Clay: French Open - popular in Europe and Latin America
- Green Clay: 1970's US Open - found in parts of North America
- Concrete/Hard Court: US Open and Australian Open - popular in North America and Australia

- What type of weather conditions would a player have to adapt to?

- What other types of conditions would a player have to overcome?

Centre Court, Wimbledon, England



STEM Jobs in Sports

- Tennis: Ball Boy/Girl
- Tennis Court - Groundskeeper
- Tennis Court/Arena Architect
- Stadium/Arena: Quality Control Coordinator
- Event/Gameday Coordinator

Fun Fact

Rafael Nadal has found great success on clay courts. With 13 French Open Title Wins, he is called the "King of Clay".

Module 3.0

Name: ____________________ Class: __________

The Playing Surface

GRADES 6-8

Engage and Explore

Surface	Rolling the Tennis Ball	Bouncing the Tennis Ball
Grass	**Benefits:** **Challenges:**	**Benefits:** **Challenges:**
Concrete (also known as a "hard surface")	**Benefits:** **Challenges:**	**Benefits:** **Challenges:**
Dirt	**Benefits:** **Challenges:**	**Benefits:** **Challenges:**

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Module 3.0

Name: ______________________________ Class: __________

The Playing Surface

GRADES 6-8

Explain

Surface	Criteria	Constraints
Grass		
Clay		
Concrete/Hard Surface		

Name: ____________________ Class: __________

The Playing Surface

GRADES 6-8

Evaluate

Surface	Based on criteria/constraints, how would a player need to adapt?
Grass	
Clay	
Concrete/Hard Surface	

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Module
4.0

GRADES
6-8

I'd Love to Keep Score

Concept
Math: Multiplication and Division of Fractions

Objective
Students will learn how to score the game of tennis through the popular theory of its correlation to an analog clock. Students will use this information to write expressions in fraction form that represent the score in a set, game, and match.

Time
(2) 50-minute blocks

Standards

Common Core State Standards Connections

CCSS.MATH.CONTENT.6.NS.A.1
Apply and extend previous understandings of multiplication and division to divide fractions by fractions.

National Standards for K - 12 Physical Education Connections

Standard 1: The physically literate individual demonstrates competency in a variety of motor skills and movement patterns.

Standard 2: The physically literate individual applies knowledge of concepts, principles, strategies and tactics related to movement and performance.

Standard 4: The physically literate individual exhibits responsible personal and social behavior that respects self and others.

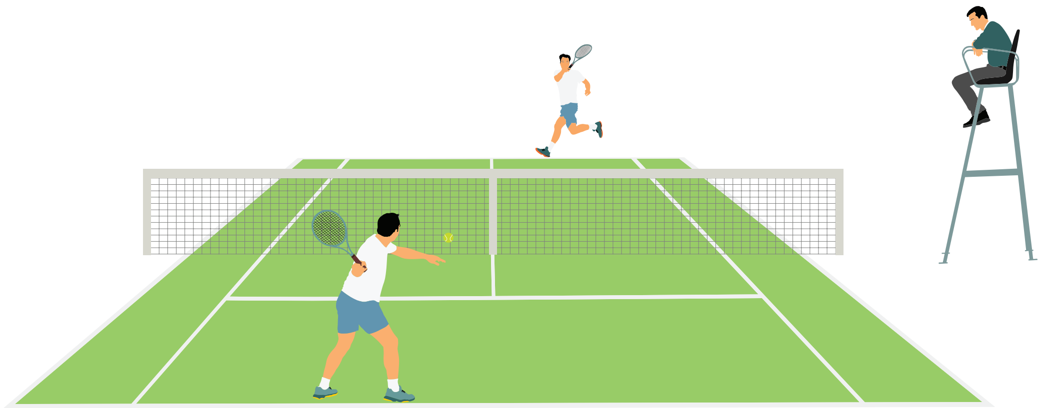
Supplies Provided
Worksheets and Article
Extend only: Tennis Rackets and Tennis Balls

Please email Info@STEMSports.com to access Worksheet Keys.

Materials Needed
Pencils
Extend only: Outdoor Space

Sequence of Lesson

Have your students take this lesson's assessment prior to engaging by visiting:
www.stemsports.com/assessments
If you have limited digital capability, please email Info@STEMSports.com to access the Assessment & Key.



Engage: Ask students to think of an image of an analog clock. What features are on this clock? What are some different ways time can be represented on this clock?

Explore: Have students read the article on pages 78-79 of "Scoring in Tennis." This history describes the correlation between scoring the game of tennis to telling the time of an analog clock.

Explain: Based on the following, have students discuss the correlation between scoring the game of tennis and telling time on an analog clock.

1. How does 1 point represent 15 minutes on a clock?
2. How does 2 points represent 30 minutes on a clock?
3. Why does 3 points not equal 45 minutes on a clock?
4. What would 4 points equal on a clock?
5. Discuss with a partner the relationship between the points scored in the game to the point system used in tennis.

Elaborate: Using the worksheet, have students complete the following in the form of a fraction:

1. If the score is love - 15 , write a fraction for each player that represents the number of points needed to win the game.
2. If the score is 15 - 30, write a fraction for each player that represents the number of points needed to win the game.
3. If the score is deuce, write a fraction for each player that represents the number of points needed to win the game.

Evaluate: Using the worksheet, have students complete the following in the form of a fraction:

1. If Player A wins the first set, write a fraction that represents the number of sets needed to win the match.
2. If Player A wins the first game, write a fraction that represents the number of games needed to win the match.
3. Write and solve an expression that can be used to represent the number of points needed to win the set.
4. Write and solve an expression that can be used to represent the number of points needed to win the match.

Have your students retake this lesson's assessment to effectively evaluate their comprehension by visiting:
www.stemsports.com/assessments
If you have limited digital capability, please email Info@STEMSports.com to access the Assessment & Key.

Extend: Students could go outside and play a mock tennis game to practice scoring, using/applying the language of scoring the game of tennis.

STEM Jobs in Sports

- Sports Statisticians
- Sports Broadcaster
- Manufacturer: Fitness Tracking Equipment
- Sports Agent
- Tennis: Line Judge

Fun Fact

In some sports, scoring zero is referred to as a "goose egg" due to the shape of the number. The French word for egg is "l'oeuf", which sounds similar to "love" and why it is used to represent zero in tennis.

Module 4.0

Name: ____________________ Class: __________

I'd Love to Keep Score

GRADES 6-8

Elaborate

Answer the following in the form of a fraction.

1. If the score is love - 15 , write a fraction for each player that represents the number of points needed to win the game.

2. If the score is 15 - 30, write a fraction for each player that represents the number of points needed to win the game.

3. If the score is deuce, write a fraction for each player that represents the number of points needed to win the game.

Evaluate

Answer the following in the form of a fraction.

1. If Player A wins the first set, write a fraction that represents the number of sets needed to win the match.

2. If Player A wins the first game, write a fraction that represents the number of games needed to win the match.

3. If the score is deuce, write a fraction for each player that represents the number of points needed to win the set.

4. Write and solve an expression that can be used to represent the number of points needed to win the match.

I'd Love to Keep Score

Like other sports, the game of tennis has its own unique way of scoring the game. Before a winner can be determined, three phases of the game must be played: a game, a set, and a match.

- A **game** is played until a player can win by reaching 4 points. A point can be earned one of five ways:

  - A player can not return a ball if the ball bounces twice.
  - A **double fault** occurs where the server misses two consecutive serves.
  - An **Ace** occurs where the player's serve is unable to be returned.
  - A ball is hit out of bounds.
  - A ball is hit into the net.

You might think the game of tennis would be scored as 0 points, 1 point, 2 points, 3 points, and 4 points. However, scoring in tennis is unlike any other sport. The first points are actually 15, 30, 40, and then the game winning point. There are many theories as to why tennis is scored this way, but one of the most popular theories is that the game of tennis, which dates back to 12th century France, was originally kept on the face of a clock. The hands of the clock would be moved from 0 minutes to 15 minutes, 30 minutes, 45 minutes, and 60 minutes to keep score.

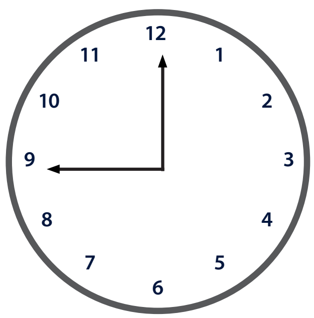
When announcing the score in tennis point zero is called **love**. There are also many theories of why the score of zero is referred to as "love," the most popular theory is that it comes from the french word "l'oeuf" which means "egg." A "l'oeuf" resembles the number zero, which is one theory why "love" is used in the game today. Point one is then called 15, point two is called 30, point three is called 40, and point four is called the game-winning point.

You might be wondering why point 3 is called 40 and not 45… Because if both players make it to point 3 or 40, the score is called "deuce". In order to win, the player must win the next two consecutive points. If a player is able to do so, the next two points would be called "advantage", then the game-winning point.

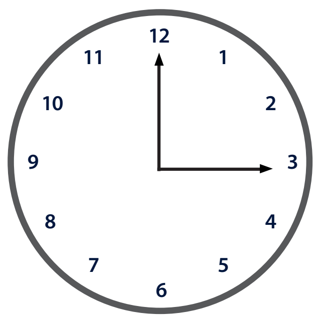
If a player wins the first point, but loses the second point, the points would be called "advantage", then back to deuce. The 40-minute mark is used to represent point 3 in the event of a deuce, letting the 45-minute mark be used to represent the player who has the advantage in the match.

When a player reaches the fourth point, the game is over. The player must win 6 games in order to win the set. Likewise, the player must win by two points to win the set and he/she must win by two games to win the match. So if a game is at 6-5, a seventh game would have to be played to determine the set winner.

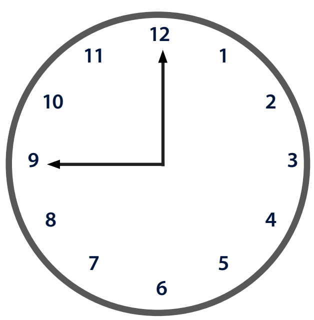
When a player reaches 2 sets won, the match is over!



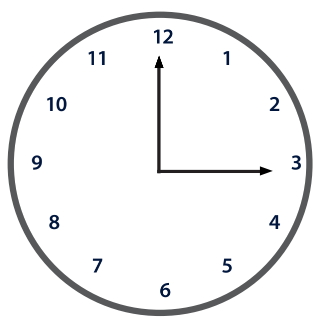
Player A



Player B



Player A



Player B

	Set 1	Set 2	Set 3	Match Winner
Player A	6	5	6	Player A
Player B	4	7	3	

Module
5.0

GRADES
6-8

May The Force Be With You!

Concept
Science: Force, Acceleration, and Mass (Newton's Second Law)

Objective
Students will calculate the force used in two different tennis motions using Newton's Second Law. Students will explain how a change in force affects the acceleration of the ball (when mass remains constant) by using experimental data to support a claim.

Time
(2) 50-minute blocks

Standards

Next Generation Science Standards Connections

MS-PS2-2
Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.

National Standards for K - 12 Physical Education Connections

Standard 1: The physically literate individual demonstrates competency in a variety of motor skills and movement patterns.

Standard 2: The physically literate individual applies knowledge of concepts, principles, strategies and tactics related to movement and performance

Standard 4: The physically literate individual exhibits responsible personal and social behavior that respects self and others.

Supplies Provided
Worksheets, Tennis Balls, Tennis Rackets, and Radar Gun

Please email Info@STEMSports.com to access Worksheet Keys.

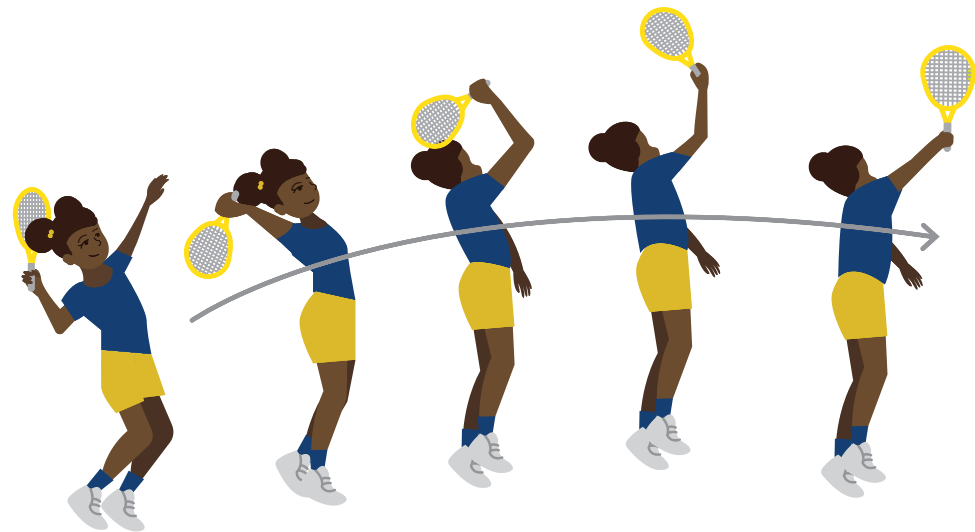
Materials Needed
Pencils and Smartphone or Tablet

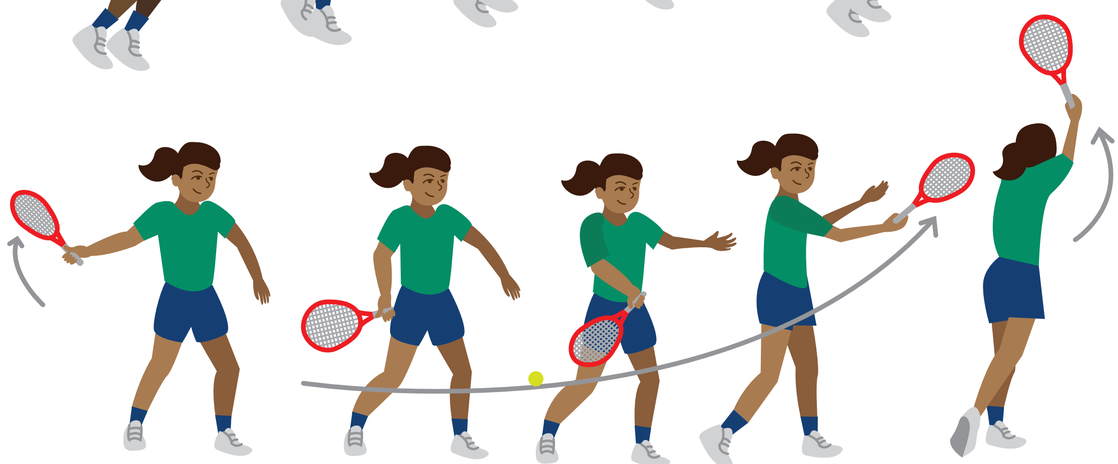
Sequence of Lesson

Have your students take this lesson's assessment prior to engaging by visiting:
www.stemsports.com/assessments
If you have limited digital capability, please email Info@STEMSports.com to access the Assessment & Key.

Engage: Have students discuss with a partner why some hitting motions are faster than others. Have students draw a diagram of a fast hitting technique. Create a list on the board with students. Encourage students to revise their ideas and to include keywords like Force and Acceleration.

Explore: Have students reference the images on page 81. Have students hit using a forehand and





hit/serve: use the images as a reference point. Then have students conduct an informal experiment to determine how to increase speed during their forehand and overhead serve. Use the Radar Gun to collect formal data, which can include observation or a rating system of slowest to fastest.

Teacher note: If students are unable to attempt an overhead serve, they may simply use their forehand to determine speed.

Explain: Define key vocabulary terms: Acceleration and Force, which can be found in the STEM Sports® Glossary in the front of this manual and at STEMSports.com under Resources. Explain the difference between speed, velocity, and acceleration: Acceleration is the change of speed over time: initial speed minus final speed divided by time. If the initial speed is zero – prior to hitting/serving the tennis ball – we can divide speed by time. Explain and demonstrate how to calculate force using Newton's Second Law: F = MA (Force equals Mass times Acceleration).

Elaborate: In groups of four, with one student measuring the time the ball is accelerating (the point from which the tennis ball comes off the racket until the ball moves downward), have students complete the following:

- The first student will video the forehand and serve using the video from a smartphone or tablet to record each student performing their hit. It is important to use a form of video and not a stopwatch, as the contact time is faster than a person can start and stop the stopwatch. By using video, students can slow down the video to accurately see actual acceleration time during the activity. Ensure students collect data in seconds.
- A second student will need to measure the speed of the ball with the radar gun. Ensure students collect and convert data in meters per second.
- A third student will need to be on the other side of the net to collect the ball.
- The fourth student will hit the ball using a forehand and overhead serve.

*For calculation of Force in Newtons (N), the units must be m/s2 for acceleration and kg for mass. The mass of a tennis ball is .06 kg. Students may measure the mass, if a scale is available.

Teacher note: Adjust the position of the student hitting the tennis ball, moving in front of the baseline/ closer to the net; the receiving student should be stationed on the opposite baseline.

Have your students retake this lesson's assessment to effectively evaluate their comprehension by visiting:
www.stemsports.com/assessments
If you have limited digital capability, please email Info@STEMSports.com to access the Assessment & Key.

Evaluate: Have students write a claim supported by their data that explains how a change in force will affect a change in motion.

Extend: Students could design their own controlled experiment by throwing the tennis ball, as their serve, as the independent variable instead of the force generated by a tennis racket. What variable generated more force?

STEM Jobs in Sports

- Head Tennis and Pickleball Professional
- Director of Junior Tennis
- USTA: Managing Director, Digital Strategy
- Tennis Rackets - Graphic Design
- Summer Camp Tennis Counselor
- Tennis Commissioner

Fun Fact

The average age of ball boys and girls serving in Wimbledon is 15 years old. Approximately 250 youth are selected to serve in the tournament each year.

Name: ______________________________ Class: __________

May the Force Be With You!

GRADES 6-8

Elaborate

What variables do you need to control?

	Speed (measured by radar) m/s	Time of travel (From video) s	Acceleration (Calculated (SI-SF)/time) m/s2	Mass kg	Force F=MA N (newtons)
Forehand					
Forehand					
Overhead Serve					
Overhead Serve					

Evaluate

How does a change in force affect a change in motion? Support your answer with evidence from the experiment.

Module
6.0

GRADES
6-8

Stroke of Energy

Concept
Science: Kinetic Energy

Objective
Students will explore the relationship between Kinetic Energy and Velocity by experimenting and recording distance and time. Students will calculate and graph their experimental data to demonstrate/ interpret the correlation of kinetic energy and velocity.

Time
(3) 50-minute blocks

Standards

Next Generation Science Standards Connections

MS-PS3-2. The physically literate individual demonstrates competency in a variety of motor skills and movement patterns.

National Standards for K - 12 Physical Education Connections

Standard 1: The physically literate individual demonstrates competency in a variety of motor skills and movement patterns.

Standard 2: The physically literate individual applies knowledge of concepts, principles, strategies and tactics related to movement and performance.

Standard 4: The physically literate individual exhibits responsible personal and social behavior that respects self and others.

Supplies Provided
Worksheets, Tennis Balls, Tennis Rackets, Sweet Spot Ball-Striking System and Manual, Tape Measures, and Digital Stopwatches

Please email Info@STEMSports.com to access Worksheet Keys.

Materials Needed
Pencils and Calculators (recommended)
Extend only: Radar Gun

Sequence of Lesson

Have your students take this lesson's assessment prior to engaging by visiting:
www.stemsports.com/assessments
If you have limited digital capability, please email Info@STEMSports.com to access the Assessment & Key.

Engage: Ask students how fast they can hit a tennis ball. Have them record their estimate on the worksheet. The fastest serve recorded was 163.4 mph or 73 meters/second.

Explore: Set-up the Sweet Spot Ball-Striking System. Tell students that Physical literacy is an essential part of sports, and by using the Sweet Spot system and Ball-Striking Game Plan, students will develop the following:

1) Consistent ball-striking: It trains the eyes to stay on the ball in the last 3 feet until contact is made;

2) Student + Athlete: It improves overall mental focus and performance in the classroom and on the court.

Now, have students form a line and take turns striking the ball on the Sweet Spot system at least 10 times, or until you feel students are demonstrating consistent ball-striking.

Have students measure from 5 meters, 8 meters, and 10 meters, and hit from these three distances. Using the worksheet, have students record the distance the ball traveled and the time it took to travel for every member in their group.

Teacher note: Distances can be altered based on age/ability.

Explain: Define key terms of Kinetic Energy and Velocity, which can be found in the STEM Sports® Glossary in the front of the manual and at STEMSports.com under Resources. Using the following formula, explain how to calculate velocity: Velocity = Distance / Time.

Elaborate: Using the worksheet as a guide, have students calculate the velocity and kinetic energy of their hits from *Explore*. The mass of a tennis ball is 0.06 kg.

Evaluate: Have students construct a graph that models the relationship between kinetic energy and speed of an object on the worksheet.

Have your students retake this lesson's assessment to effectively evaluate their comprehension by visiting:
www.stemsports.com/assessments
If you have limited digital capability, please email Info@STEMSports.com to access the Assessment & Key.

Extend: Using the radar gun, students could hit a ball from 5 meters, 8 meters, and 10 meters, recording the velocity shown on the App. Students could then compare the calculations completed by-hand in *Elaborate* and *Evaluate* to the velocity from the Pitch Counter App. What could cause a difference in these numbers?

STEM Jobs in Sports

- General Manager: Tennis Club
- Tennis Pro: Personal Trainer & Coach
- Baseball Scout
- Tennis Racket Engineer
- High School Physics Teacher and Track & Field Coach

Fun Fact

The fastest serve recorded was 163.4 mph or 73 meters/second.

Module 6.0

Name: ____________________ Class: __________

Stroke of Energy

GRADES 6-8

Explore/Elaborate

Student: ____________________

	Distance (meters)	Time (seconds)	Velocity (meters/second^2)	Kinetic Energy (Joules)
Hit #1				
Hit #2				
Hit #3				

Student: ____________________

	Distance (meters)	Time (seconds)	Velocity (meters/second^2)	Kinetic Energy (Joules)
Hit #1				
Hit #2				
Hit #3				

Student: ____________________

	Distance (meters)	Time (seconds)	Velocity (meters/second^2)	Kinetic Energy (Joules)
Hit #1				
Hit #2				
Hit #3				

Name: ______________________________ Class: __________

Stroke of Energy

GRADES 6-8

Evaluate

Use your data from the *Explore* and *Elaborate* sections to graph the relationship between velocity (x - coordinate) and Kinetic Energy (y - coordinate).

Describe the correlation between velocity and kinetic energy of the tennis ball.

____

____

____

Module 7.0

GRADES 6-8

Let's Serve

Concept
Math: Percentages
Use of Technology

Objective
Students will learn the rules and strategies of serving in tennis. Students will use technology to find the speed of their serve. Students will analyze the speed and accuracy of their first serve to compare to their second serve.

Time
(2) 50-minute blocks

Standards

Common Core State Standards Connections

CCSS.MATH.CONTENT.6.RP.A.3.C. Find a percent of a quantity as a rate per 100 (e.g., 30% of a quantity means 30/100 times the quantity)

CCSS.MATH.CONTENT.8.SP.A.1 Find a percent of a quantity as a rate per 100 (e.g., 30% of a quantity means 30/100 times the quantity)

National Standards for K - 12 Physical Education Connections

Standard 1: The physically literate individual demonstrates competency in a variety of motor skills and movement patterns.

Standard 2: The physically literate individual applies knowledge of concepts, principles, strategies and tactics related to movement and performance.

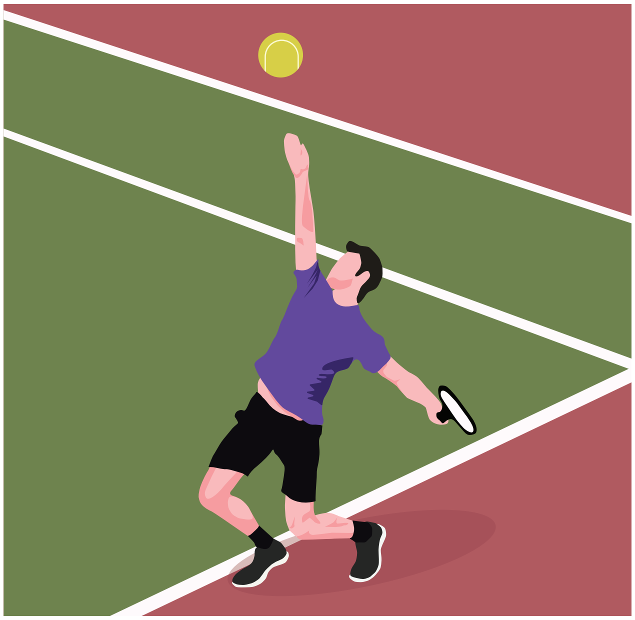
Standard 4: The physically literate individual exhibits responsible personal and social behavior that respects self and others.

Supplies Provided
Worksheets, Tennis Balls, Tennis Rackets, and Radar Gun

Please email Info@STEMSports.com to access Worksheet Keys.

Materials Needed
Pencils, Tennis Court, and Radar Gun

Videos
The Rule of Tennis Explained:
stemsports.com/resources/resources-tennis/



Sequence of Lesson

Have your students take this lesson's assessment prior to engaging by visiting:
www.stemsports.com/assessments
If you have limited digital capability, please email Info@STEMSports.com to access the Assessment & Key.

Engage: Ask students: If you get two attempts to serve the ball in bounds, how confident are you that you could do this? What if you only get one try?

Explore: Have students go outside to the tennis court. Ask students to identify the parts of the court relevant when serving, such as: Service Box, Service Line, Center Service Line, and Sideline

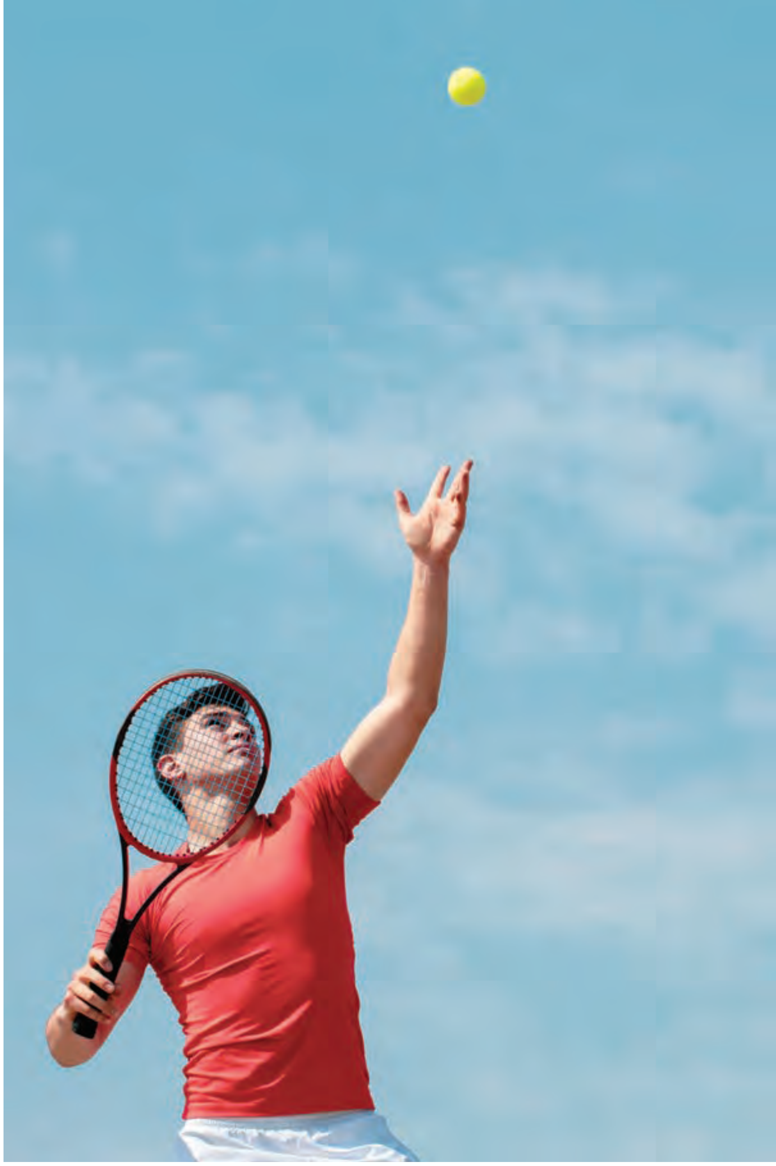
Explain: Show students the video on the rules of tennis, which can be found at STEMSports.com, then click on STEM Tennis under Resources. Pinpoint and focus on the rules and positioning of serving with students. Tell them that depending on what side of the court they choose to serve, will determine what service box they will hit the ball to. Reference back to the video and explain to students what serve would be considered In, Out, or Let.

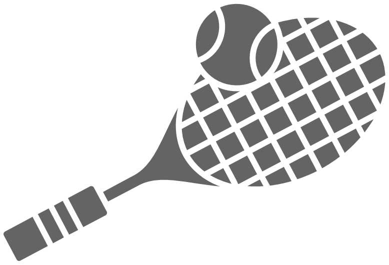
Elaborate: Have students hit 10 serves and measure the speed of each serve using a radar gun. If a student does not hit his/her first serve in, they must serve their second serve. Use the worksheet as a guide.

Teacher note: Service line distance can be altered based on age/ability.

Evaluate: Have students answer the questions on the worksheet.

Extend: Review key terms of independent and dependent variables with students, which can be found in the STEM Sports® Glossary in the front of the manual and at STEMSports.com under Resources. Then ask students to graph the relationship between the number of serves and the speed of the serve. Using the STEM Sports® Glossary, discuss specific features of a graph, such as clustering, outliers, positive correlation, negative correlation, no correlation, linear association, and nonlinear association. Have students answer the questions on the worksheet.





STEM Jobs in Sports

- Tennis Scout
- Scoreboard Operator
- Middle School: Math Teacher and Tennis Coach
- Team Videographer
- Tennis - Statistical Analyst

Fun Fact

Arthur Ashe was the first African American to win the US Open in 1968.

Module 7.0

Name: ____________________ Class: __________

Let's Serve

GRADES 6-8

Elaborate

First Serve			Second Serve (only needed if first serve is not inbounds)	
Serve Number	Speed	Result In - Out - Let	Speed	Result In - Out - Let
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

Evaluate

Answer the following in the form of a fraction.

1. What was the probability you hit your first serve in? Write your answer as a ratio, decimal, and percentage.

2. What was the probability your hit your second serve in? Write your answer as a ratio, decimal, and percentage.

3. What was the maximum and minimum speeds of your first serves? How does this compare to your second serve?

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Name: ______________________________ Class: __________

Let's Serve

GRADES 6-8

Extend

Using your data from *Elaborate*, construct a scatterplot where the independent variable is your number of serves and the dependent variable is your speed. Use two different colors to represent the first serve attempt and second serve attempt for each serve.

4. Discuss the features of the scatterplot:
    a. Clustering
    b. Outliers
    c. Type of correlation (positive/negative/none)
    d. Type of association (linear/nonlinear)

Module
8.0

GRADES
6-8

Advancements in Tennis

Concept
Engineering Design Process
Use of Technology

Objective
Students will examine the use of instant replay in tennis. Students will evaluate instant replay technology by using steps of the Engineering Design Process, such as brainstorming and developing a list of criteria and constraints. Students will write a letter based on their findings to determine if the needs of all stakeholders are being met.

Time
(2-3) 50-minute blocks

Standards

Next Generation Science Standards Connections

MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

National Standards for K - 12 Physical Education Connections

Standard 1: The physically literate individual demonstrates competency in a variety of motor skills and movement patterns.

Standard 2: The physically literate individual applies knowledge of concepts, principles, strategies and tactics related to movement and performance.

Standard 4: The physically literate individual exhibits responsible personal and social behavior that respects self and others.

Supplies Provided
Worksheets, Tennis Rackets, and Tennis Balls

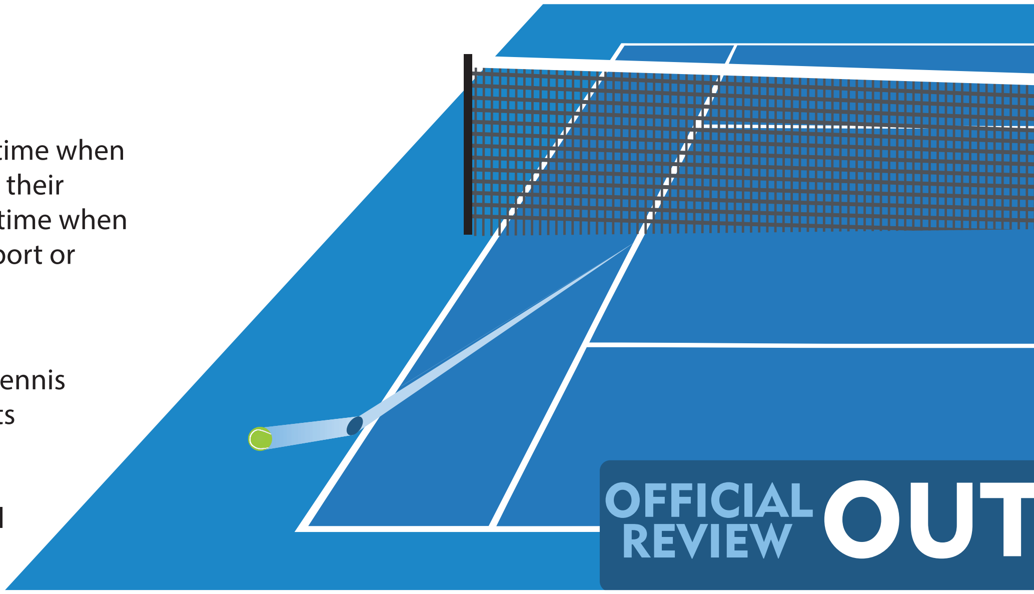
Please email Info@STEMSports.com to access Worksheet Keys.

Materials Needed
Pencils and Smartphone or Tablet

Video
Video Replay Option #3: stemsports.com/resources/resources-tennis/

Sequence of Lesson

Have your students take this lesson's assessment prior to engaging by visiting:
www.stemsports.com/assessments
If you have limited digital capability, please email Info@STEMSports.com to access the Assessment & Key.



Engage: Ask students to think of a time when they wish they had "instant replay" in their daily lives. Ask students to think of a time when instant replay could be helpful in a sport or sports; specifically, tennis.

Explore: Ask students to go to the tennis courts. In groups of 3-4, have students perform and rotate for the following practice: one student will hit the ball over the net, one or two students will determine if the ball is in or out and record results on the worksheet, and one student will video record each hit using a smartphone or tablet to watch the results frame-by-frame.

Ask students to discuss their results of each shot. Did all team members agree their hits were in or out? What were some pro's and con's of using technology during this process?

Teacher note: Adjust hitting distance based on age/ability.

Explain: Tell students tennis uses a form of technology called "Hawk-Eye instant review" and that it is used when a player challenges the call of the line judge or chair umpire. Explain to them that Hawk-Eye technology has both a positive and negative impact on the game.

Then discuss the Engineering Design Process with students. Using the worksheet as a guide, have students continue brainstorming with their groups from *Explore*, writing down criteria and constraints using technology in tennis, such as Hawk-Eye. Tell students to consider the players, officials, and spectators when creating this list.

Elaborate: Have students watch the video on instant replay, which can be found at STEMSports.com, then click on STEM Tennis under Resources. After watching the video, have students add to their lists of criteria and constraints of using replay technology.

Evaluate: After students have brainstormed, have them write a letter to the USTA (United States Tennis Association). The letter should take a stance for supporting or opposing the use of instant replay in tennis. The letter should include specific changes and improvements to benefit all stakeholders: players, officials, and spectators.

Example Prompts: Does using Hawk-eye technology make the game of tennis more fair? How does or does not using Hawkeye meet the needs of all stakeholders? Does the game of tennis need line judges and chair officials?

Have your students retake this lesson's assessment to effectively evaluate their comprehension by visiting:
www.stemsports.com/assessments
If you have limited digital capability, please email Info@STEMSports.com to access the Assessment & Key.

Extend: Students could present their letter to the class, which could include a small group reading the letter, a gallery walk of the letters, or a small group Q & A.

STEM Jobs in Sports

- Team Photographer
- Internet - Sports Producer
- Tennis Developer (IT) - Tennis Data and Development
- Director of Broadcast Technology
- Tennis Commissioner

Fun Fact

Did you know that if the ball hits a player's body or any part of their clothing before it lands, it is their opponent's point (even if it would have gone out)?

Module 8.0

Name: ______________________ Class: __________

Advancements in Tennis

GRADES 6-8

Explore

X = In O = Out

	Hit 1	Hit 2	Hit 3	Hit 4	Hit 5	Hit 6	Hit 7	Hit 8
Line Judge 1								
Line Judge 2								
Video Judge								

Explain/Elaborate

Criteria	Constraints
______________________	______________________
______________________	______________________
______________________	______________________
______________________	______________________
______________________	______________________

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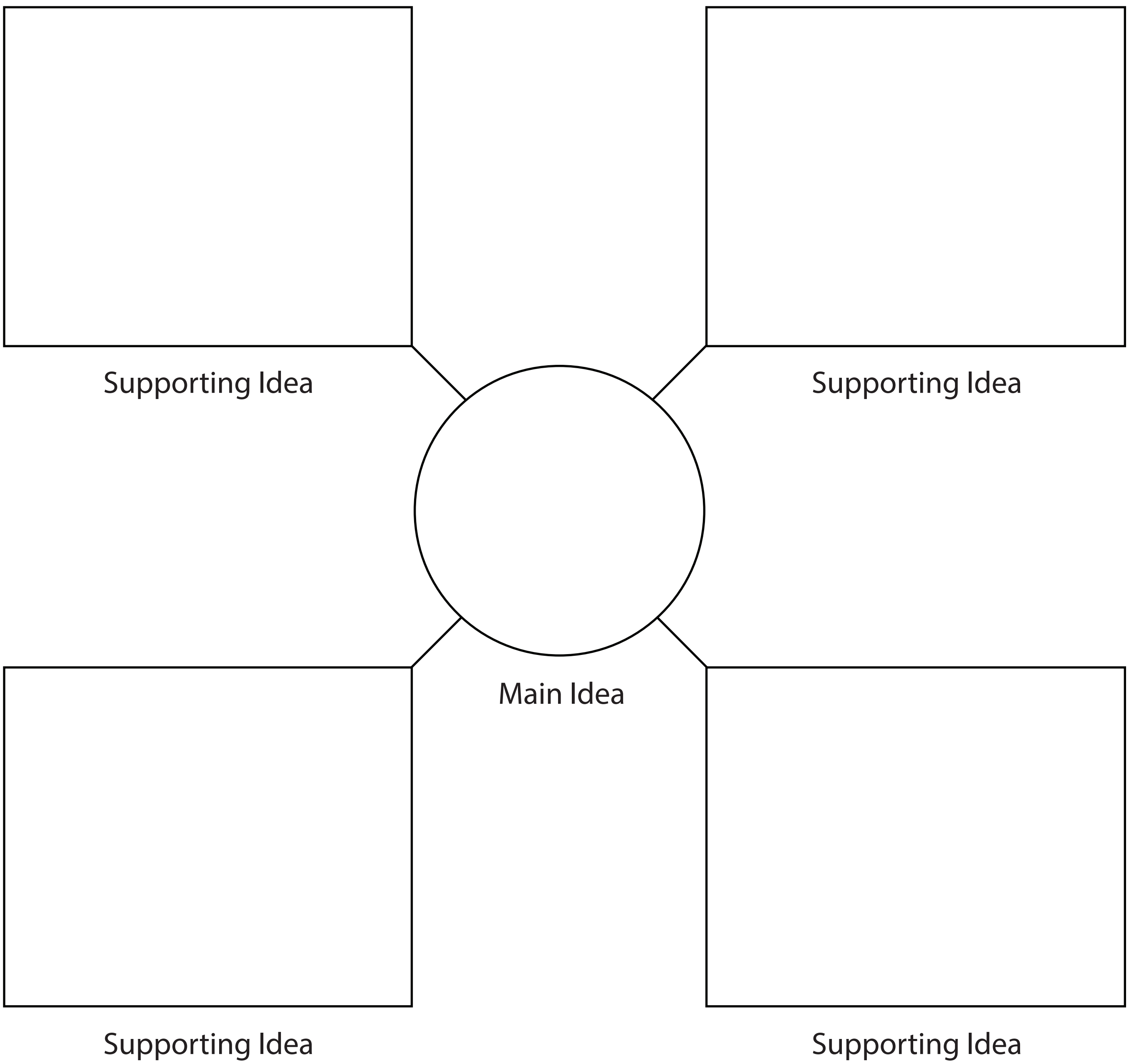
Name: ______________________ Class: ___________

Advancements in Tennis

GRADES 6-8

Evaluate

Use the below graphic organizer to create an outline of your letter to the USTA (United States Tennis Association).



Name: ________________________________ Class: __________

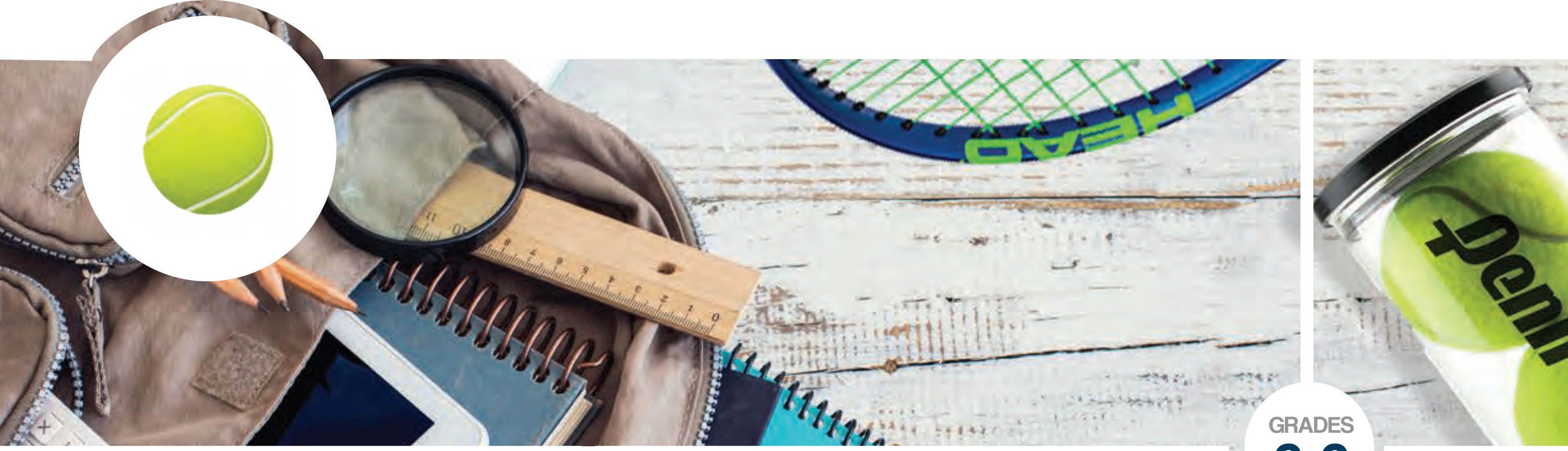
Advancements in Tennis

GRADES 6-8

Evaluate

Have students write a letter to the USTA (United States Tennis Association). The letter should take a stance for supporting or opposing the use of instant replay in tennis. The letter should include specific changes and improvements to benefit all stakeholders involved: players, officials, and spectators.

STEM sports
science • technology
engineering • math • sports



GRADES
6-8

Capstone

Concept: Engineering Design Process

Objective: Students will use the Engineering Design Process to design a solution for getting more youth interested in Tennis, with a focus on challenges and obstacles for accessible playing areas.

Standards

Next Generation Science Standards Connections

MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions

MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

MS-ETS1-3. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

Supplies Provided

Peer Feedback Form

Materials Needed

Pencils and Poster Board; Optional: Prototyping Materials; Technical access: PowerPoint and Video

Video

How to sort the Court: stemsports.com/resources/resources-tennis/

Maps

Tennis Maps: stemsports.com/resources/resources-tennis/

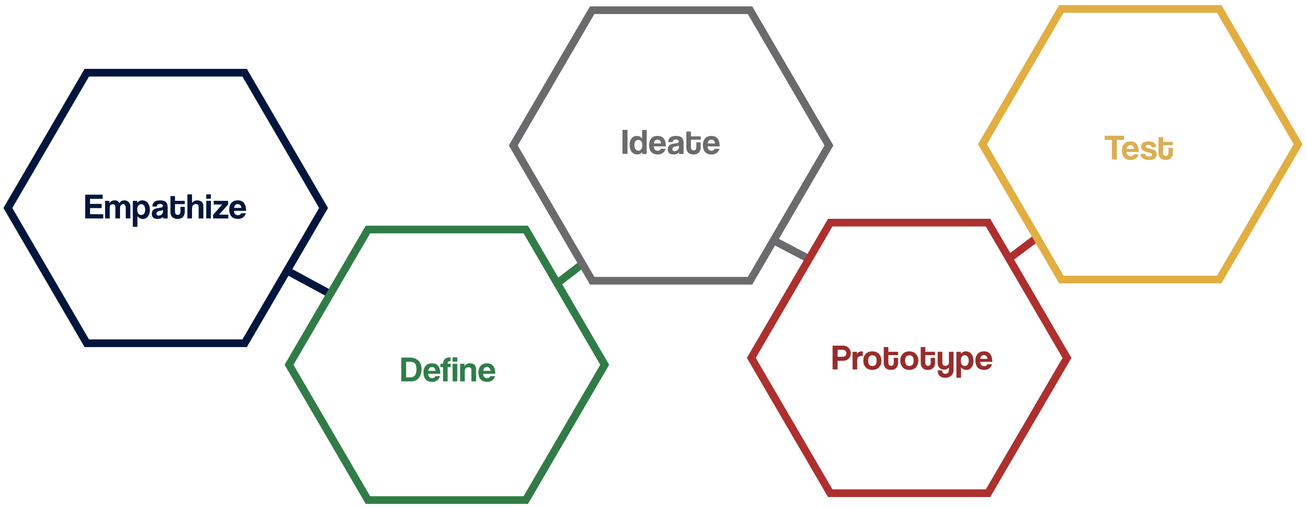
Sequence of Lesson

Engage: Have students interview a friend or family member who doesn't play tennis, focusing on why they don't play tennis:

- What are the barriers?
- Why didn't they play as a child, in high school, etc?
- Do they watch it?
- Other sports?

Explore: Go to https://stemsports.com/resources/resources-tennis/ and search the tennis courts in your area.

- How many are available within walking distance?
- Pick another city: How many are available within walking distance? Why do you think this is similar or different?



- Use the video on how to sort the court: stemsports.com/resources/resources-tennis/
- - How many of the courts are public access?
  - How many are private access?

Have students fill in the data table using Tennis Maps. Then have students calculate the percent of public and private courts in their city and several major cities.

Explain: Social engagement is an essential part of sports, including tennis. Using the engineering design process (EDP), explain how it can be modified to help combat social challenges. This is also referred to as "design thinking". Likewise, the EDP steps are close to and can be used for the same purpose. Using the pie graph on "Who Plays Tennis?" on page 99, have students review the U.S. map and cities below it on page 100 to create a t-chart of similarities.

Design Challenge: How can you get more people interested in playing tennis or increase access to courts?

Explain to students that in the *Explore* section we empathize and collect data to define the challenges. Now we will review some claims and articles to define the challenges and objectives.

Explain to students the following claims that define the challenges and objectives of the design challenge:

- Tennis has been considered an "elitist" sport for many years. The main reason is because tennis was first accessed by private clubs (paid with a membership).
- Tennis enthusiasts have tried to change the face of tennis to be a sport for everyone.
- There are many more parks and recreation centers to access tennis courts throughout the U.S. today.
- In some communities, there is a need for more courts, but leaders are reluctant to build additional courts. Their claim is that tennis courts have a large footprint and don't allow as many players as a basketball court.

Teacher note: In addition, students can conduct research to find evidence that either supports or refutes these claims.

Elaborate: Have students ideate and prototype parts of design thinking. Two options may include:

Design a court that could be built in a small park with multiple uses: https://www.versacourt.com/residential-court-design.html

Design a marketing campaign to get more kids interested and excited about tennis.

Evaluate: Have students test their prototype by presenting their ideas to the class.

Students can use poster boards, PowerPoint slides, video, roleplay, prototype a tennis court, etc. Have students complete the "What works?" form for feedback on the test.

Extend: Based on classmates and teacher feedback, students could present their findings to the local Parks & Recreation Department and/or the local municipality/governing body.

Tennis Courts

Across the World

3,000
Number of tennis courts in London, England

338
Number of tennis courts in Sydney, Australia

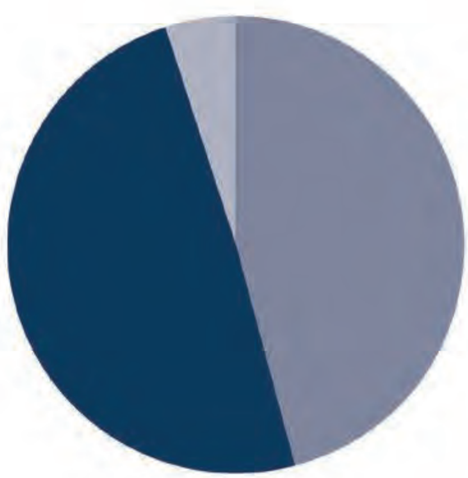
142
Number of tennis courts in Paris, France

Who Plays Tennis?

49%
MEN

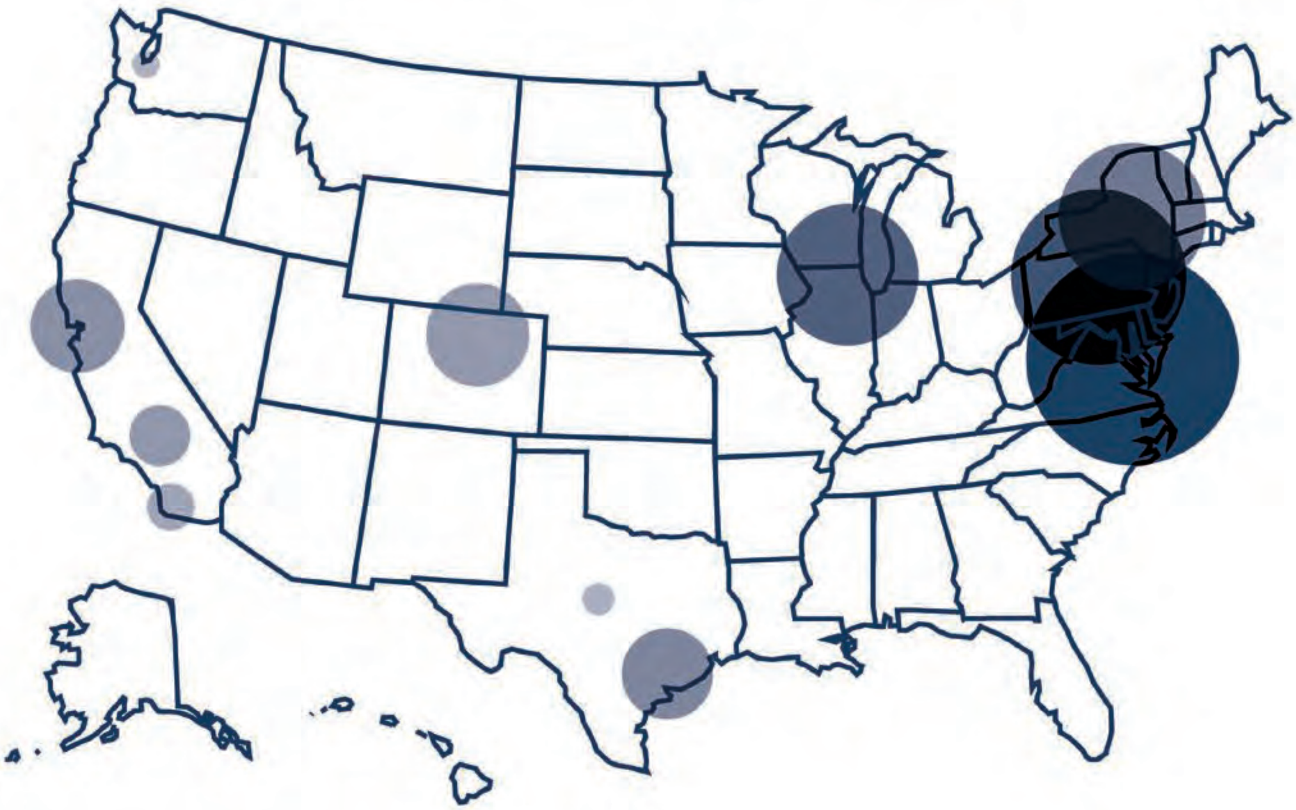
46%
WOMEN

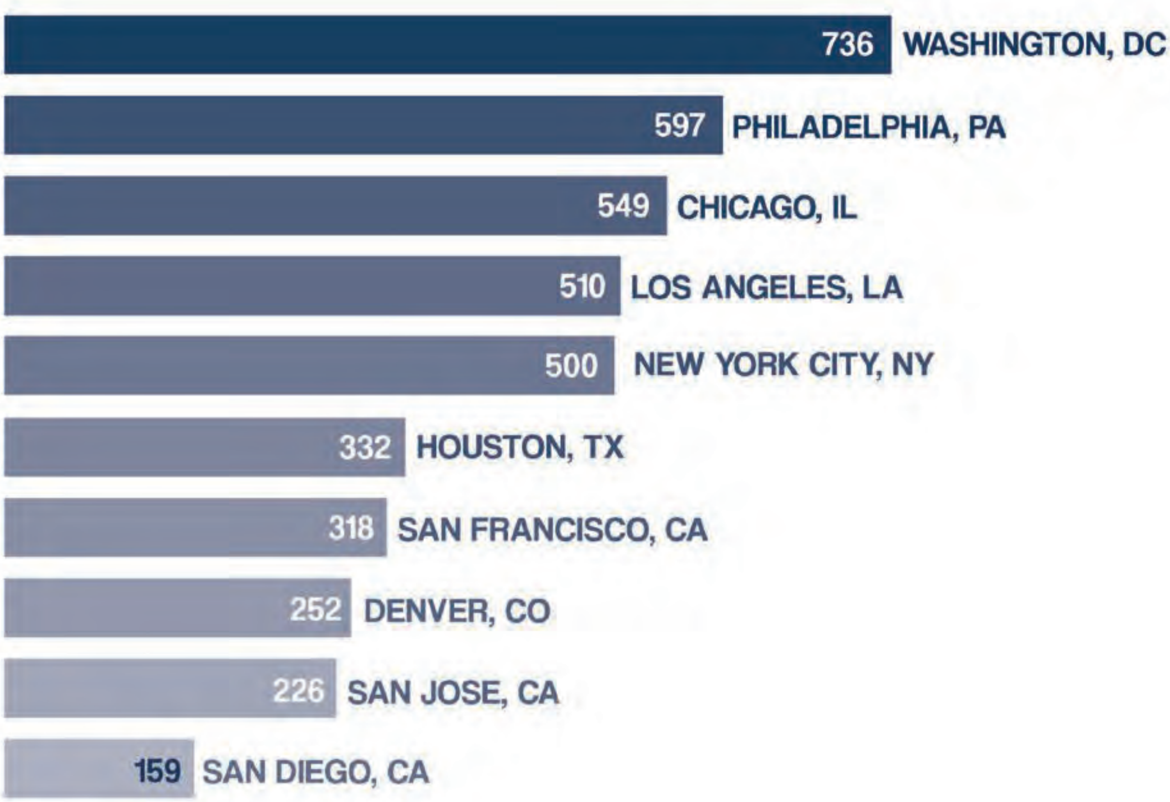
5%
UNKOWN



The truth is... everyone can play tennis! How would you set up a tennis court in your neighborhood?

Tennis Courts in Major US Cities





Name: ______________________ Class: ________

Capstone

GRADES 6-8

Peer Feedback Form

Group Member Names:

____

____

____

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Circle the assignment you chose:

Design a Court **Create a Marketing Campaign**

1. What do you think will work best about their plan?

2. What part of the plan do you think could use improvement?

3. If you were in their group, what would you do next?

Notes

Notes

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