

BODY MECHANICS OF SPORT

First edition

8 units

32 lessons

A video for every lesson

FIRST EDITION

COURSE GUIDE

Body Mechanics of Sport is a one-year course for students in grades 4–7 about how the human body moves in play and sport. It begins with the body itself: bones and joints that work like levers, muscles that pull, the center of gravity that keeps us balanced, and the “kinetic chain” that passes speed from the legs to the hips to the shoulder to the hand like the crack of a whip. Then it visits six sports one at a time: bowling, tennis, golf, volleyball, baseball and softball, and soccer.

Every lesson follows the same path. First comes **the story**: a real person, place and date, such as Charles Blondin balancing over Niagara Falls in 1859, Harry Vardon’s famous grip, or William G. Morgan inventing volleyball at the Holyoke YMCA in 1895. Then **how they figured it out**: what coaches and scientists noticed, measured or tested. Then **the physics**, explained simply: levers, balance, pendulums, momentum, spin and bounce. Last comes **on the field**, where the student learns how players use the idea and then practices it at home with a balloon, a soft ball, plastic bottles, a broomstick in the yard or a phone camera.

God made the human body with wonderful care. “I will praise thee; for I am fearfully and wonderfully made” (Psalm 139:14). Learning how it moves teaches us to thank Him for it, to take care of it, and to use it well in work and play. The course ends with a family field day, where the student runs a station for every sport and shows guests what he or she has learned.

Videos were chosen lesson by lesson from official coaching programs (the USBC’s National Bowling Academy, the PGA, USA Volleyball and youth soccer and tennis programs), halls of fame, science channels such as SciShow Kids, Smarter Every Day and TED-Ed, and established coaching channels. Each one was previewed frame by frame and its description read. Volleyball and tennis videos were picked for practice clothing and plain teaching; videos of the sand version of volleyball were left out entirely. No video carries sponsors or advertising unsuitable for children. Some coaching channels end

with an invitation to subscribe or a short advertisement for their own lessons; you can stop the video when the teaching ends. The “when” note tells you when to watch.

Start with Lesson 1.1 →

WHO IT IS FOR

Written for students in grades 4–7 (about ages 9–13). A 9-year-old can follow every lesson with a parent reading along; a 12-year-old can read most of it alone. No sports experience is needed, and no equipment needs to be bought: every drill uses household items such as balloons, soft or foam balls, empty plastic bottles, a broomstick or plastic club used outdoors, a tape measure and a phone camera if the family has one. Optional books and games are listed in some units.

HOW TO USE THIS COURSE

1. **The weekly rhythm.** The year has 32 lessons, one a week. Session 1 (about 45 minutes) is the warm-up, the video, the teaching and the picture study. Session 2 (about 45 minutes) is the project and the scorebook. In the last week of each unit, add a third session for the unit review and the portfolio.
2. **The story, how they figured it out, the physics, on the field.** The core ideas are written to be read aloud or read by the student. After each paragraph, ask the student to tell it back in his or her own words, and to stand up and show the movement it describes.
3. **Picture study.** Each lesson has one public-domain painting, drawing or historic photograph. Look at it quietly for two minutes. Then put it away and tell everything you remember. Bring it back and work through the “look for” items and questions, which point to the body mechanics in the picture: where the weight is, which joint is bending, where the eyes are looking.
4. **The scorebook.** Keep one graph-paper notebook for the year. For every project, write a prediction first, then record every try in a tally or table, then write what happened and what you will change. Date every page. Honest records matter more than good scores.
5. **Practice makes progress.** Most projects ask the student to measure a skill, practice it carefully, and measure it again. Slow, careful repetitions with one thing to fix are worth more than many careless ones.

6. **Unit review and portfolio.** Each unit ends with a short review (50 points) and a portfolio piece, such as a balance-challenge chart, a bottle-bowling league sheet, a putting-course map or a coaching card for a younger child.
7. **Safety.** Read the safety box before every physical lesson. Warm up first. Use balloons and soft balls indoors, clear a space away from windows, lamps, stairs and people, and wear proper shoes. Bats, clubs and broomsticks are swung only outdoors, with a clear circle and an adult watching. Young players never head a real soccer ball in this course; heading is shown only with a balloon. If anything hurts, stop and tell a parent.
8. **Optional books and games.** Some units list free books, governing-body coaching guides and family games. They are never required.
9. **The family field day.** In the last week, the student runs a field day with one station from every unit and keeps score in the scorebook.

SCOPE AND SEQUENCE

UNIT 1 • WEEKS 1–4

Your Amazing Body

Bones, joints and muscles as levers (Borelli, 1680); balance and the center of gravity (Blondin over Niagara, 1859); the kinetic chain and the crack of a whip; and how careful practice builds skill.

- 1.1 Bones, Joints and Muscles: Levers in Your Body
- 1.2 Balance and the Center of Gravity
- 1.3 The Kinetic Chain: Your Body's Whip
- 1.4 Practice Makes Progress

UNIT 2 • WEEKS 5–8

Bowling

From skittles to tenpins; the four-step approach; the arm swing as a pendulum (Galileo); and aiming, spares and a bottle-bowling alley at home.

- 2.1 From Skittles to Tenpins
- 2.2 The Four-Step Approach
- 2.3 The Pendulum Swing
- 2.4 Aim, Spares and a Household Bowling Alley

UNIT 3 • WEEKS 9–12

Tennis

From the jeu de paume to Wimbledon (1877); the ready position and split step; the forehand with a balloon and a soft ball; and the serve as a throwing motion.

- 3.1 From the Jeu de Paume to Wimbledon
- 3.2 The Ready Position and the Split Step
- 3.3 The Forehand
- 3.4 The Serve Is a Throw

UNIT 5 • WEEKS 17–20

Volleyball

William G. Morgan's game at the Holyoke YMCA (1895); the forearm pass with a balloon; the set; and why you hit through the ball on a serve.

- 5.1 Morgan's Game: Holyoke, 1895
- 5.2 The Forearm Pass with a Balloon
- 5.3 The Set
- 5.4 The Serve: Hit Through the Ball

UNIT 7 • WEEKS 25–28

Soccer

Passing with the inside of the foot; the instep kick; dribbling and balance; and why young players don't head the ball (the balloon lesson).

- 7.1 Passing with the Inside of the Foot
- 7.2 The Instep Kick
- 7.3 Dribbling and Balance
- 7.4 Why Young Players Don't Head the Ball

UNIT 4 • WEEKS 13–16

Golf

Old Tom Morris and St Andrews; Harry Vardon's grip and a good stance; the pendulum putt on a household putting course; and the full swing with a broomstick outdoors.

- 4.1 Old Tom Morris and St Andrews
- 4.2 Grip and Stance: Vardon's Grip
- 4.3 The Pendulum Putt
- 4.4 The Full Swing with a Broomstick

UNIT 6 • WEEKS 21–24

Baseball and Softball

Throwing with the whole body; catching soft by "giving" with the ball; the level swing with a foam bat; and why curveballs curve (the Magnus effect).

- 6.1 Throwing with the Whole Body
- 6.2 Catching Soft
- 6.3 The Level Swing
- 6.4 Why Curveballs Curve

UNIT 8 • WEEKS 29–32

Practice, Safety and a Field Day

Warming up and cooling down; water, rest and sleep; filming a skill to check it (Muybridge's galloping horse, 1878); and a family field day with stations from every unit.

- 8.1 Warm Up and Cool Down
- 8.2 Water, Rest and Sleep
- 8.3 Filming a Skill to Check It
- 8.4 A Family Field Day

WEEKLY PACING CALENDAR

WEEK	PLAN
1	• Session 1: Lesson 1.1 Bones, Joints and Muscles: Levers in Your Body: warm-up, video, teaching and picture study • Session 2: Lesson 1.1 project and scorebook <i>Two sessions a week is the usual rhythm. Younger children can split a long session in two; older students can do both sessions in one sitting.</i>
2	• Session 1: Lesson 1.2 Balance and the Center of Gravity: warm-up, video, teaching and picture study • Session 2: Lesson 1.2 project and scorebook
3	• Session 1: Lesson 1.3 The Kinetic Chain: Your Body's Whip: warm-up, video, teaching and picture study • Session 2: Lesson 1.3 project and scorebook
4	• Session 1: Lesson 1.4 Practice Makes Progress: warm-up, video, teaching and picture study • Session 2: Lesson 1.4 project and scorebook • Session 3: Unit 1 review and portfolio project
5	• Session 1: Lesson 2.1 From Skittles to Tenpins: warm-up, video, teaching and picture study • Session 2: Lesson 2.1 project and scorebook
6	• Session 1: Lesson 2.2 The Four-Step Approach: warm-up, video, teaching and picture study • Session 2: Lesson 2.2 project and scorebook
7	• Session 1: Lesson 2.3 The Pendulum Swing: warm-up, video, teaching and picture study • Session 2: Lesson 2.3 project and scorebook
8	• Session 1: Lesson 2.4 Aim, Spares and a Household Bowling Alley: warm-up, video, teaching and picture study • Session 2: Lesson 2.4 project and scorebook • Session 3: Unit 2 review and portfolio project

WEEK	PLAN
9	- Session 1: Lesson 3.1 From the Jeu de Paume to Wimbledon: warm-up, video, teaching and picture study - Session 2: Lesson 3.1 project and scorebook
10	- Session 1: Lesson 3.2 The Ready Position and the Split Step: warm-up, video, teaching and picture study - Session 2: Lesson 3.2 project and scorebook
11	- Session 1: Lesson 3.3 The Forehand: warm-up, video, teaching and picture study - Session 2: Lesson 3.3 project and scorebook
12	- Session 1: Lesson 3.4 The Serve Is a Throw: warm-up, video, teaching and picture study - Session 2: Lesson 3.4 project and scorebook - Session 3: Unit 3 review and portfolio project
13	- Session 1: Lesson 4.1 Old Tom Morris and St Andrews: warm-up, video, teaching and picture study - Session 2: Lesson 4.1 project and scorebook
14	- Session 1: Lesson 4.2 Grip and Stance: Vardon's Grip: warm-up, video, teaching and picture study - Session 2: Lesson 4.2 project and scorebook
15	- Session 1: Lesson 4.3 The Pendulum Putt: warm-up, video, teaching and picture study - Session 2: Lesson 4.3 project and scorebook
16	- Session 1: Lesson 4.4 The Full Swing with a Broomstick: warm-up, video, teaching and picture study - Session 2: Lesson 4.4 project and scorebook - Session 3: Unit 4 review and portfolio project
17	- Session 1: Lesson 5.1 Morgan's Game: Holyoke, 1895: warm-up, video, teaching and picture study - Session 2: Lesson 5.1 project and scorebook
18	- Session 1: Lesson 5.2 The Forearm Pass with a Balloon: warm-up, video, teaching and picture study - Session 2: Lesson 5.2 project and scorebook

WEEK	PLAN
19	• Session 1: Lesson 5.3 The Set: warm-up, video, teaching and picture study • Session 2: Lesson 5.3 project and scorebook
20	• Session 1: Lesson 5.4 The Serve: Hit Through the Ball: warm-up, video, teaching and picture study • Session 2: Lesson 5.4 project and scorebook • Session 3: Unit 5 review and portfolio project
21	• Session 1: Lesson 6.1 Throwing with the Whole Body: warm-up, video, teaching and picture study • Session 2: Lesson 6.1 project and scorebook
22	• Session 1: Lesson 6.2 Catching Soft: warm-up, video, teaching and picture study • Session 2: Lesson 6.2 project and scorebook
23	• Session 1: Lesson 6.3 The Level Swing: warm-up, video, teaching and picture study • Session 2: Lesson 6.3 project and scorebook
24	• Session 1: Lesson 6.4 Why Curveballs Curve: warm-up, video, teaching and picture study • Session 2: Lesson 6.4 project and scorebook • Session 3: Unit 6 review and portfolio project
25	• Session 1: Lesson 7.1 Passing with the Inside of the Foot: warm-up, video, teaching and picture study • Session 2: Lesson 7.1 project and scorebook
26	• Session 1: Lesson 7.2 The Instep Kick: warm-up, video, teaching and picture study • Session 2: Lesson 7.2 project and scorebook
27	• Session 1: Lesson 7.3 Dribbling and Balance: warm-up, video, teaching and picture study • Session 2: Lesson 7.3 project and scorebook
28	• Session 1: Lesson 7.4 Why Young Players Don't Head the Ball: warm-up, video, teaching and picture study • Session 2: Lesson 7.4 project and scorebook • Session 3: Unit 7 review and portfolio project

WEEK	PLAN
29	• Session 1: Lesson 8.1 Warm Up and Cool Down: warm-up, video, teaching and picture study • Session 2: Lesson 8.1 project and scorebook
30	• Session 1: Lesson 8.2 Water, Rest and Sleep: warm-up, video, teaching and picture study • Session 2: Lesson 8.2 project and scorebook
31	• Session 1: Lesson 8.3 Filming a Skill to Check It: warm-up, video, teaching and picture study • Session 2: Lesson 8.3 project and scorebook
32	• Session 1: Lesson 8.4 A Family Field Day: warm-up, video, teaching and picture study • Session 2: Lesson 8.4 project and scorebook • Session 3: Unit 8 review and portfolio project <i>Last week. Hold a family game day: the student runs the culminating event from Unit 8 and shows guests the scorebook and the best project from each unit.</i>

MATERIALS

Balloons (a bag of round 9–12 inch balloons)

For tennis, volleyball and heading drills indoors. Balloons move slowly, so beginners have time to get their bodies in position. Keep broken balloon pieces away from small children.

Soft balls

A foam ball, a soft playground ball or rolled-up socks for throwing and catching; a beach ball or soft volleyball trainer for volleyball; a soccer ball (size 4 or 5) used outdoors.

Ten empty plastic bottles

Two-liter or 500 ml drink bottles become bowling pins; add a little water or sand to the bottom for steadier pins.

A broomstick or plastic golf club, and a plastic or foam bat

Swung only outdoors, with a clear circle and an adult watching. A wooden spoon or a paper-towel tube works as a tennis “racket” for balloon drills.

A golf ball or ping-pong ball, and a cup or mug

For the household putting course in Unit 4.

Masking tape, chalk, a tape measure and a stopwatch (or a phone)

For marking lines, targets and distances and for timing drills.

A phone or tablet camera (optional)

For filming a skill in slow motion and checking it. Every project also works with a partner who watches and describes.

A graph-paper notebook (the scorebook), pencils and a ruler

For predictions, tallies, tables and drawings.

GRADING

Grades come from the projects, the scorebook, the eight unit reviews and the portfolio pieces. Effort, honest records and improvement count more than athletic talent: a student who measures a skill carefully, practices it and measures it again earns full credit even if he or she is not the fastest or strongest.

PART	%
Projects (done safely, measured and recorded)	40
Scorebook (predictions, tallies, drawings and reflections)	20
Unit reviews	15
Portfolio pieces	25

Scale: A 90–100, B 80–89, C 70–79, D 60–69, F below 60.

- A project earns full credit when the student made a prediction, followed the safety rules, recorded every try honestly, and wrote what he or she would change.
- Each unit review is worth 50 points. Give partial credit for a correct idea explained in the student's own words, even if a word is missing.
- Grade portfolio pieces with the rubric in each unit. Neatness matters less than clear, accurate explanation.
- Never grade on strength, speed or natural ability. Grade improvement, care and understanding.

A NOTE TO PARENTS

You do not need to be an athlete or a coach to teach this course. Your jobs are to read along with younger students, keep the weekly rhythm, set up a safe space for each project, and watch the drills. The best questions you can ask are “Show me,” “What did you measure?” and “What will you change next time?” A child who can show you a movement and explain why it works is learning body mechanics.

Safety comes first in every physical lesson. Each one has a safety note: read it before you begin. Use balloons and soft balls indoors and clear a space away from windows, lamps and stairs. Anything that is swung (a bat, a broomstick or a club) is used only outdoors with a clear circle and an adult watching. Following U.S. Soccer’s youth guidelines, this course never asks a child to head a real soccer ball; heading is shown with a balloon only. If anything hurts, the child stops and tells you. The course gives no medical advice, so ask your doctor about any health question.

The course also teaches gratitude and stewardship. Our bodies are a gift, “fearfully and wonderfully made,” and the Bible says that “bodily exercise profiteth little: but godliness is profitable unto all things” (1 Timothy 4:8). Exercise has real value, and godliness has more. Praise careful practice, honest scorekeeping and good sportsmanship more than winning, and enjoy playing together.

UNIT 1

YOUR AMAZING BODY

Before you learn to bowl, serve, putt, pass, throw or kick, you need to know the machine that does all of those things: your own body. In this unit you will discover that your bones and joints work like levers, the same simple machines that lift heavy loads and move things fast. You will learn where your center of gravity is, why a tightrope walker carries a long pole, and why bending your knees makes you harder to knock over.

Then you will learn the secret of every powerful throw, swing and kick: the kinetic chain, which passes speed from the legs to the hips to the shoulder to the hand like the crack of a whip. Last, you will learn how practice really works, and why ten careful tries teach more than fifty careless ones. God made your body “fearfully and wonderfully” (Psalm 139:14). This unit will help you see how wonderfully.

PREREQUISITES

- Can measure with a ruler and a tape measure in centimeters
- Can make a tally chart and find an average of a few numbers (or can learn with a parent)
- Has a clear indoor space and, if possible, a yard or park for throwing

MASTERY CHECKLIST

- ☐ I can name the three parts of a lever and find a lever in my arm, my leg and my neck.
- ☐ I can explain what the center of gravity is and show three ways to make myself more stable.
- ☐ I can explain the kinetic chain and show it in a throw, from my feet to my fingers.
- ☐ I can measure a skill, practice it carefully, and measure it again to see my progress.
- ☐ I can keep an honest scorebook with predictions, tallies and what I will change.

OPTIONAL BOOKS AND GAMES FOR THIS UNIT

- **KidsHealth: Your Muscles:** Free. A clear article for children from Nemours KidsHealth on how muscles pull, work in pairs and grow stronger. Fits Lesson 1.1. Ages 8 and up.
- **KidsHealth: Your Bones:** Free. Bones, joints and how they grow, written for children. Fits Lessons 1.1 and 1.2. Ages 8 and up.

Not required. Every project in this unit works without them. School Launch has no ties to these authors, publishers or companies.

LESSONS IN THIS UNIT

1.1	Bones, Joints and Muscles: Levers in Your Body	2 sessions of 45 minutes
1.2	Balance and the Center of Gravity	2 sessions of 45 minutes
1.3	The Kinetic Chain: Your Body's Whip	2 sessions of 45 minutes
1.4	Practice Makes Progress	2 sessions of 45 minutes

UNIT 1 REVIEW

Answer each question in complete sentences. Show your work for the calculation. You may stand up and act out a movement to help you think. The review is worth 50 points.

1. **5 pts**
Name the three parts of a lever, and tell what plays each part when you bend your elbow to lift a ball.
2. **5 pts**
Why do muscles work in pairs?
3. **5 pts**
Your biceps attaches 3 cm from the elbow, and your hand is 30 cm from the elbow. If the muscle moves 1 cm, about how far does the hand move?

4. (5 pts)

What is the center of gravity, and where is it in a person standing straight?

5. (5 pts)

Give three ways to make yourself more stable.

6. (5 pts)

What would happen if Blondin's center of gravity moved to one side of the rope and he did nothing about it? What did his pole do to help?

7. (5 pts)

Put these in the right order for a good throw: elbow, step, wrist, hips, shoulder, trunk.

8. (5 pts)

Explain how the game Snap the Whip shows the kinetic chain.

9. (5 pts)

What would happen if a player threw with only the arm? Give two results.

10. (5 pts)

Describe deliberate practice in your own words, and tell why "practice makes permanent" is a better saying than "practice makes perfect."

ANSWER KEY

1. Fulcrum: the elbow joint. Effort: the biceps muscle pulling on the forearm.
Load: the ball in the hand (and the forearm itself).
2. Muscles can only pull, not push. One muscle pulls a bone one way (the biceps bends the elbow) and its partner pulls it back (the triceps straightens it).
3. $30 \div 3 = 10$, so the hand moves about 10 times as far: about 10 cm.
4. The balance point, where the body's weight acts as if it were all in one spot. In a standing person it is just below the belly button, in the middle of the body.
5. Widen the base of support (feet apart); lower the center of gravity (bend the knees); keep the center of gravity over the middle of the base.
6. He would tip and fall off that side. The long pole made him tip slowly, giving him time to correct, and moving the pole let him shift his balance point back over the rope.
7. Step, hips, trunk, shoulder, elbow, wrist.
8. The boys near the center move slowly and pass their motion along the line; each boy farther out goes faster, and the last boy goes fastest, just as speed passes from the legs and hips out to the hand in a throw.
9. The ball would go slower and shorter, and the shoulder and elbow would have to work too hard, which can strain them.
10. Practice with one clear goal, full attention, quick feedback and many careful repetitions. Whatever you repeat becomes a habit, good or bad, so only careful practice makes progress.

PORTFOLIO PIECE: MY BODY MECHANICS HANDBOOK, PART 1

Make a four-page illustrated handbook titled “How My Body Moves.” Give one page to each lesson: levers (with your cardboard arm drawing), balance (with your balance-lab graph), the kinetic chain (with your throwing graph) and practice (with your before-and-after target drawings). On each page, write a short explanation in your own words and one tip you would give a younger child. Keep the handbook in a folder; you will add to it at the end of the year.

LOOK FOR	WHAT IT MEANS
Accurate ideas	Each page explains its idea correctly, using the words lever, center of gravity, base of support, kinetic chain or deliberate practice.
Real data	Each page includes the student’s own measurements, table or graph from the project.
Clear drawings	Drawings are labeled and help explain the idea.
Helpful tips	Each page has a sensible, safe tip a younger child could follow.

1.1 BONES, JOINTS AND MUSCLES: LEVERS IN YOUR BODY

OBJECTIVES

- Name the three parts of a lever (the fulcrum, the effort and the load) and find them in the elbow, the ankle and the neck.
- Explain why muscles can only pull, and why they work in pairs.
- Build a cardboard model arm and measure how a small muscle movement makes a big hand movement.

Warm-up. Put your left hand on the front of your right upper arm. Slowly bend and straighten your right elbow. What do you feel getting fat and hard when you bend? Now put your hand on the back of your upper arm and push your fist down against a table. What do you feel now? Write your guess: how many bones do you think are in your body?

WATCH

How Do Our Bodies Move?

SciShow Kids · 3:35

<https://www.youtube.com/watch?v=j918PoWWaB0>

WHEN TO WATCH

After the story, before the physics. Watch for the word “joint.”

BACKUP VIDEO

The 3 Classes of Levers || How we use levers in the world and our bodies || By: Kinesiology Kris

KinesiologyKris · 6:17

https://www.youtube.com/watch?v=A0y_2b8SSbs

After the physics paragraph, for students who want to see all three classes of levers in the body with real examples.

KEY TERMS

lever

A stiff bar that turns around a fixed point. Your bones are levers.

fulcrum

The fixed point a lever turns around. In your body, the fulcrum is a joint.

effort

The push or pull that moves a lever. In your body, the effort is a muscle pulling on a bone.

load

What the lever moves: a ball in your hand, your own arm, or your whole body.

joint

A place where two bones meet. Hinge joints (elbow, knee) bend one way; ball-and-socket joints (shoulder, hip) swing in many directions.

tendon

A tough cord that ties a muscle to a bone.

CORE IDEAS

The story. In the 1600s, an Italian scientist named Giovanni Alfonso Borelli asked a question nobody had answered well: how does an animal move? Borelli was a mathematician who loved the new science of machines. He studied men lifting weights, birds flapping and fish swimming, and he drew the bones of the arm and leg as if they were the beams and pulleys of a machine. He spent the last years of his life in Rome, living with a community of Christian teachers who ran free schools for poor children, and teaching mathematics there. His great book, *De Motu Animalium* (“On the Movement of Animals”), was printed in 1680, the year after he died. He is often called the father of biomechanics, the science of how living bodies move.

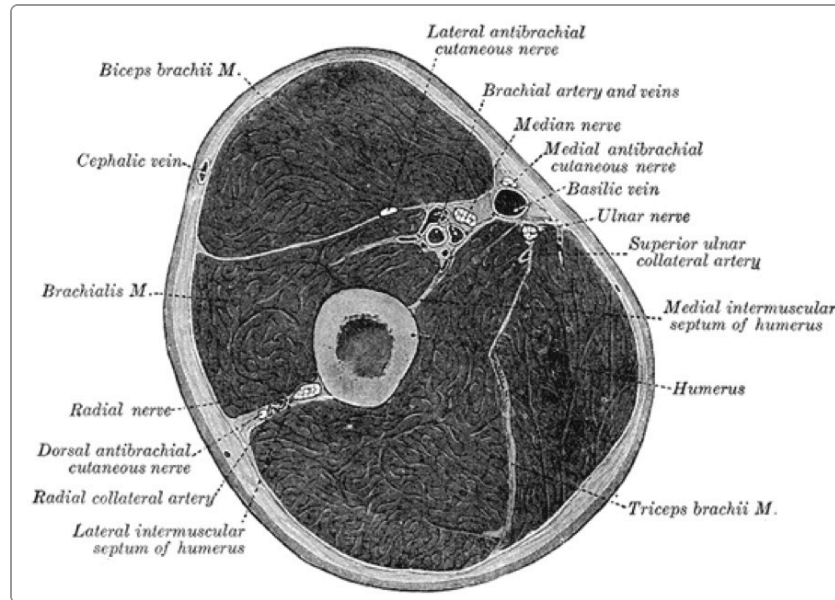
How they figured it out. Borelli measured where muscles attach to bones. He noticed something surprising. The biceps muscle, which bends your elbow, is fastened to your forearm only a few centimeters from the elbow, while your hand is much farther away. That means the muscle has to pull very hard to lift even a light load in your hand. Why would God design an arm that way? Borelli worked out the answer: because a short pull near the joint makes the hand move a long way, very fast. Your arm trades strength for speed, and speed is exactly what you need to throw, swing and catch.

The physics. Every lever has three parts: a **fulcrum** (the turning point), an **effort** (the push or pull) and a **load** (what gets moved). In your body, the joint is the fulcrum, a muscle is the effort and the load is whatever you are moving. Your neck is a first-class lever: the fulcrum is in the middle, like a seesaw, when you nod your head. Rising up on your toes is often taught as a second-class lever: the load is in the middle, like a wheelbarrow. Your elbow is a third-class lever: the muscle pulls

between the fulcrum and the load. Muscles can only **pull**, never push, so they come in pairs. The biceps on the front of your arm pulls to bend the elbow; the triceps on the back pulls to straighten it. A grown-up has 206 bones and more than 600 muscles, all fitted together.

On the field. Athletes use their levers every second. A longer lever moves its end faster: that is why a tennis racket, a golf club and a bat make the ball fly farther than a bare hand. Coaches teach players to keep a joint bent while it is loading (a knee before a jump, an elbow before a throw) and then straighten it quickly. Strong muscles help, but good use of the levers helps more. When you understand your levers, you understand why a small change in how you hold a club or bend a knee can make a big change in where the ball goes.

PICTURE STUDY



Cross-Section of the Upper Arm, Henry Vandyke Carter and later illustrators, for Gray's *Anatomy*, Figure from the 1918 American edition (first edition 1858) · Engraving in a printed textbook · Published in Philadelphia

Image: [Wikimedia Commons](#), public domain

In 1858 the English doctor Henry Gray published a textbook of anatomy with careful drawings by his friend Henry Vandyke Carter. *Gray's Anatomy* has been used by doctors and nurses ever since. This drawing shows what the upper arm would look like if you could slice straight across it, as you would slice a loaf of bread, and look at the cut end.

Look closely

- Find the round bone in the middle. It is the humerus, the upper-arm bone, and the long, stiff bar of your arm's lever.
- Find the biceps on the front side and the triceps on the back side. Which one bends the elbow, and which one straightens it?
- Notice how much of the arm is muscle. Why do you think the muscles are wrapped all around the bone?
- Find the small circles labeled artery, vein and nerve. What do they carry to the muscles?

Talk about it

1. Why do the biceps and triceps sit on opposite sides of the bone?

2. If muscles could only pull, how would your arm straighten without the triceps?
3. Borelli had no drawings like this one. How would a picture like this have helped him?

Safety first. Use only light loads in this lesson, such as a can of soup or a bag of rice. Move slowly, and stop if anything hurts and tell a parent. An adult helps with the brass fasteners and any cutting.

PROJECT

A Cardboard Arm That Lifts

You will build a working model of your arm, with a cardboard upper arm and forearm, a brass-fastener elbow and a string “biceps.” Then you will measure how far the string moves and how far the hand moves, and test what happens when you attach the muscle closer to or farther from the elbow.

You will need

- Two strips of stiff cardboard, about 4 cm wide: one 25 cm long (upper arm) and one 30 cm long (forearm)
- One brass paper fastener (brad) for the elbow, and a hole punch or sharp pencil (adult helps)
- String or yarn, about 60 cm, and tape
- A paper clip for the “hand” to hold a small load such as a few coins
- A ruler, pencil and the scorebook

Steps

1. Join the two cardboard strips at one end with the brass fastener so they bend like an elbow. Lay the upper arm flat on the table and tape its top end down.
2. Punch three holes in the forearm: 3 cm, 6 cm and 9 cm from the elbow. These are three places the “biceps” could attach.
3. Tie the string through the 3 cm hole. Run it up along the upper arm and through a small loop of tape near the top, so pulling the string lifts the forearm.
4. Bend a paper clip into a hook and tape it to the end of the forearm as the hand. Hang a few coins from it.
5. **Predict.** If you pull the string 2 cm, how far will the hand rise? Write your guess.
6. Mark the string with a pen at the tape loop. Pull it exactly 2 cm and measure how far the hand rises. Record it.
7. Move the string to the 6 cm hole and then the 9 cm hole. Each time, pull 2 cm and measure. Also notice: was it easier or harder to lift the coins?

8. Make a table: attachment distance, string pulled, hand movement, and “easy or hard.”
9. Find your own arm’s numbers. With a parent’s help, measure from your elbow to the middle of your palm. Feel for your biceps tendon at the inside of your elbow and estimate how far it is from the joint.

Tips

- Keep the fastener a little loose so the elbow turns freely.
- If the forearm flops, tape a craft stick along it to make it stiffer, just as bone is stiff.

Check your work

- ☐ I can point to the fulcrum, the effort and the load on my model.
- ☐ I measured that the hand moves farther than the string when the string is close to the elbow.
- ☐ I can explain why a muscle attached close to the joint gives speed but needs strength.

SCOREBOOK

1. Draw your arm as a lever. Label the fulcrum (elbow), effort (biceps) and load (ball in the hand).
2. Copy your project table and circle the attachment point that made the hand move farthest. Then circle the one that made lifting easiest. Are they the same?
3. Lever hunt: list five levers in your body and five in your house (scissors, a door, a seesaw). Mark each one first, second or third class.

From history. Long before Borelli, the Greek mathematician Archimedes explained the law of the lever and is remembered for saying that with a long enough lever he could move the world. Borelli’s gift was to see that same law inside the human arm.

WORKED EXAMPLES

Example 1. Your biceps attaches about 4 cm from your elbow. Your hand is about 32 cm from your elbow. If your biceps shortens by 1 cm, about how far does your hand move?

Show solution

1. Compare the two distances: $32 \text{ cm} \div 4 \text{ cm} = 8$.
2. Everything on the lever turns together, so the hand moves 8 times as far as the muscle's attachment point.
3. $1 \text{ cm} \times 8 = 8 \text{ cm}$.

Answer: About 8 cm. A small pull near the joint makes a big, fast movement at the hand.

Example 2. Using the same arm, you hold a 1-kilogram bag of rice in your hand with your forearm level. About how hard must your biceps pull?

Show solution

1. The hand is 8 times farther from the elbow than the muscle is.
2. To balance the lever, the muscle must pull 8 times harder than the load: $1 \text{ kg} \times 8 = 8 \text{ kg}$.
3. (This is a simple estimate. It leaves out the weight of the forearm itself, which makes the real pull even larger.)

Answer: About 8 kilograms of pull, at least. Your arm trades strength for speed.

COMMON MISTAKES

- Thinking muscles can push. Muscles only pull; a different muscle pulls the other way.
- Mixing up the fulcrum and the load. The fulcrum is the part that stays put while everything turns around it.

Make it a game • Lever Charades. Act out an everyday motion without speaking: lifting a grocery bag, nodding, rising onto tiptoes. Your partner points to the fulcrum, the effort and the load on your body and names the joint. One point for each part named correctly. First to ten wins. Parents: once per game, name a wrong part and see if the student catches it.

Scripture. “I will praise thee; for I am fearfully and wonderfully made: marvellous are thy works; and that my soul knoweth right well.” (Psalm 139:14, KJV)

Every lever in your arm was placed with care. Learning how your body moves is one way to praise the One who made it.

1.2 BALANCE AND THE CENTER OF GRAVITY

OBJECTIVES

- Explain what the center of gravity and the base of support are.
- Show three ways to make the body more stable: a wider base, a lower center of gravity and keeping the center of gravity over the base.
- Test balance in different stances and record the results in a table.

Warm-up. Stand with your heels and back against a wall. Without moving your feet or bending your knees, try to bend forward and touch your toes. What happens? Now step away from the wall and try again. Why was it impossible against the wall?

WATCH

What Is Center Of Gravity? (Mr. Wizard)

[Official Mr.Wizard's World Channel](#) · 2:24

<https://www.youtube.com/watch?v=02DI3WLEjxw>

WHEN TO WATCH

After the story. Then try the challenge yourself with a yardstick before you read the physics.

BACKUP VIDEO

Physics of Football - Center of Gravity

[Mississippi State Athletics](#) · 1:36

<https://www.youtube.com/watch?v=2WUdHBso3Vk>

A short demonstration with a football player of why a low, wide stance is hard to push over.

KEY TERMS

center of gravity

The balance point of an object or a body, where its weight acts as if it were all gathered in one spot. In a standing person, it is just below the belly button.

base of support

The area under you outlined by the parts touching the ground: your two feet and the space between them.

stable

Hard to tip over. An object is stable when its center of gravity stays over its base of support.

athletic stance

Feet about shoulder-width apart, knees bent, weight on the balls of the feet: the ready position in almost every sport.

CORE IDEAS

The story. On June 30, 1859, a French acrobat named Jean-François Gravelet, who called himself Charles Blondin, stepped onto a rope stretched across the gorge below Niagara Falls. The rope was about 335 meters (1,100 feet) long and hung about 50 meters (160 feet) above the rushing water. Thousands of people watched. In his hands Blondin carried a long, heavy balancing pole. He walked across, and over the next two summers he crossed again and again: blindfolded, pushing a wheelbarrow, on stilts, and once carrying his manager, Harry Colcord, on his back.

How they figured it out. Blondin did not have a science book; he had years of practice. But scientists can explain why his tricks worked. Every object has a **center of gravity**, the spot where its weight balances. If that spot stays over what is holding it up, it stays up. On a rope the width of a thumb, Blondin's base was tiny, so he had to keep his center of gravity exactly above the rope. His long pole helped in two ways. It is hard to start a long pole turning quickly, so any tip happened slowly and gave him time to correct it. And by sliding the pole a little left or right, he could move the balance point back over the rope.

The physics. You stay standing when your **center of gravity** is above your **base of support**, the area outlined by your feet. When it moves outside that area, you tip, unless you step to make a new base. There are three ways to be more stable. First, **widen your base**: stand with your feet apart. Second, **lower your center of gravity**: bend your knees. Third, **keep your center over the middle of your base**, not near an edge. That is why you could not touch your toes against the wall: as you bent forward, your center of gravity moved out over your toes, and the wall would not let your hips move back to balance it.

On the field. Almost every sport begins from the same **athletic stance**: feet about shoulder-width apart, knees bent, weight on the balls of the feet. It is stable enough to take a bump but ready to move in any direction. A soccer player dribbling, a tennis player waiting for a serve and a volleyball player ready to pass all stand this

way. To move fast, an athlete lets the center of gravity lean just outside the base on purpose and then steps to catch it. Running is really falling forward and catching yourself, again and again.

PICTURE STUDY



Charles Blondin, Charles Reutlinger, 1860s or 1870s · Photograph (carte de visite) · Paris; Musée Carnavalet

Image: [Wikimedia Commons](#), public domain

After his Niagara crossings, Blondin became famous across Europe and America. The Paris photographer Charles Reutlinger made this small portrait card of him in his street clothes, wearing medals he had been given for his performances. Cards like this were collected and traded the way some people collect sports cards today.

Look closely

- Look at how he stands. Is his weight on one foot or both? Is his body straight up and down?
- Look at his feet. How wide apart are they?
- Find the cane. Does he need it for balance, or is it just for style?
- Find the medals. What do they tell you about how people honored him?

Talk about it

1. Even standing still, Blondin keeps his center of gravity over his base. Where is it in this photograph?
2. On the rope, his base was only as wide as the rope. How did his long pole make up for that?

3. Blondin practiced for years before he crossed Niagara. Why is this not a stunt anyone should copy?

Safety first. Do the balance tests on carpet or grass, away from furniture corners, stairs and windows, with a partner ready to steady you. Never practice balancing on anything high, such as a wall, railing or furniture. Stop if you feel dizzy.

PROJECT

The Balance Lab

You will test how long you can balance in different stances, and find out which changes make you more stable. A partner times and records; then you switch.

You will need

- A stopwatch or phone timer
- Masking tape for a straight line on the floor
- A pool noodle, yardstick or broom handle (for a “balancing pole” test)
- A partner and the scorebook

Steps

1. Make a table with these rows: (1) feet together, (2) one foot, arms out, (3) one foot, arms folded, (4) one foot, eyes closed, (5) one foot, holding the pole across your body.
2. **Predict.** Number the tests from easiest to hardest before you begin.
3. For each stance, your partner times how long you can hold it, up to 60 seconds. Stop the clock when you put a foot down or move your arms out of position.
4. Do each test three times and write down the middle time.
5. Push test: stand normally with feet together. Have your partner give a gentle, steady push on your shoulder. Then stand in an athletic stance (feet wide, knees bent) and repeat with the same gentle push. Which is harder to move?
6. Walk heel-to-toe along the tape line 3 meters long, once with arms at your sides and once holding the pole. Count how many times you step off the line.
7. Switch places and test your partner.
8. Write a sentence about each result using the words “center of gravity” and “base of support.”

Tips

- Look at one spot on the wall when balancing on one foot. Your eyes help your balance, which is why closing them makes it so much harder.

- Gentle pushes only: the goal is to feel stability, not to knock anyone over.

Check your work

- ☐ I tested five stances and recorded three times for each.
- ☐ I can explain why the athletic stance is harder to push over.
- ☐ I can explain what the pole did to my balance.

SCOREBOOK

1. Draw a stick figure in three positions (feet together, wide stance, wide stance with bent knees). Mark the center of gravity with a dot and shade the base of support.
2. Copy your balance table and make a bar graph of the middle times.
3. Write about one sport you know and describe its ready stance. Why is it shaped that way?

From history. Blondin crossed Niagara many times in 1859 and 1860 and performed for more than thirty more years in many countries. He practiced rope walking from the age of five. His stunts are a lesson in how much practice lies behind any skill that looks easy.

COMMON MISTAKES

- Thinking “stable” means “stiff.” A good stance has bent, springy knees.
- Standing with feet very wide. Too wide makes it hard to move quickly; about shoulder-width is usually best.

Make it a game • Wobble Duel. Take turns holding a pose on one foot while a parent tries to name what would make it steadier. You answer in one sentence using base of support or center of gravity. Then change the pose: wider feet, lower knees, arms out. Count seconds held in each version, and try to beat your own best time.

1.3 THE KINETIC CHAIN: YOUR BODY'S WHIP

OBJECTIVES

- Explain the kinetic chain: speed passed from big, slow body parts to small, fast ones, one after another.
- Show the order of a good throw: step, hips, trunk, shoulder, elbow, wrist.
- Measure how much farther a soft ball goes when the whole body joins the throw.

Warm-up. Sit on a chair with your back against it and throw a pair of rolled-up socks as far as you can using only your arm. Mark where it lands. Now stand, step forward with the opposite foot and throw again. How much farther did it go? Which parts of your body joined in the second throw?

WATCH

How does a whip break the sound barrier? (Slow Motion Shockwave formation) - Smarter Every Day 207

[SmarterEveryDay](#) · 11:21

https://www.youtube.com/watch?v=AnaASTBn_K4

WHEN TO WATCH

After the story. Watch how the loop travels down the whip and gets faster as the whip gets thinner.

Note: The video ends with a short sponsor message for an audiobook service; you can stop when the teaching ends.

BACKUP VIDEO

Why is Cracking a Whip So Loud?

[The Royal Institution](#) · 5:49

<https://www.youtube.com/watch?v=DGH3GMiHNls>

A shorter explanation of why a whip cracks, from the Royal Institution in London.

KEY TERMS

kinetic chain

The linked parts of the body (legs, hips, trunk, shoulder, arm, hand) that pass speed from one to the next in a throw, swing or kick.

momentum

How hard it is to stop something moving. Heavy, fast things have a lot of it.

sequence

The order in which body parts move. In a good throw, the big parts start first and the small parts finish last.

follow-through

The movement after the ball is released or struck, which lets the body slow down safely.

CORE IDEAS

The story. In 1872 the American painter Winslow Homer painted a group of country schoolboys playing a game called Snap the Whip. The boys hold hands in a long line and run. Then the leader at one end stops short and pulls. The line swings around, each boy going faster than the one before, until the boys at the far end are flung off their feet. Children played this game for many years before anyone could explain it. A real whip works the same way, and its tip goes so fast that the crack you hear is a tiny sonic boom: the tip is moving faster than sound, more than 340 meters every second. Scientists first photographed that boom in 1927.

How they figured it out. When a whip is snapped, a loop runs down it from the thick handle to the thin tip. As the loop moves into thinner and lighter parts of the whip, the motion is squeezed into less and less material, so it goes faster and faster. In 2002 two mathematicians at the University of Arizona, Alain Goriely and Tyler McMillen, worked out the exact shape and speed of that traveling loop. Sports scientists noticed that good throwers, hitters and kickers move the same way: heavy body parts start the motion, and light, fast parts finish it. They call this the **kinetic chain**.

The physics. Your legs and hips are big and heavy. They cannot move very fast, but they can get a lot of **momentum** going. Your hand is small and light. If the speed from your big parts is passed along in the right order, each lighter part moves faster than the one before. In a good throw, the order is: step with the opposite foot, turn the hips, turn the trunk, bring the shoulder around, then the elbow, then snap the wrist. Each part speeds up, then slows down as it hands its speed to the next, like the

boys in Snap the Whip. If a link is skipped or comes at the wrong time, speed is lost, and the arm has to work too hard on its own.

On the field. A big-league pitcher can throw faster than 90 miles per hour, and most of that speed starts in his legs. Tennis players use the same chain to serve, golfers to drive, soccer players to kick and volleyball players to hit. Coaches watch for a player who “throws with just the arm,” because that player throws more slowly and can strain his shoulder or elbow. Learning the chain is the best way to throw faster **and** more safely.

PICTURE STUDY



Snap the Whip, Winslow Homer, 1872 · Oil on canvas · Metropolitan Museum of Art, New York

Image: [Wikimedia Commons](#), public domain

Winslow Homer grew up in New England and painted ordinary American life after the Civil War. In *Snap the Whip*, boys from a one-room country school play during recess. Homer painted two versions of this scene in 1872. This is the smaller one, in New York's Metropolitan Museum of Art; the larger one hangs in the Butler Institute of American Art in Ohio.

Look closely

- Find the boys who are planted in place at the center of the line. How are their feet set?
- Follow the line out to its end. Which boys are going fastest? What has happened to the last ones?
- Look at the angles of the boys' bodies. Who is leaning back to hold on, and who is being pulled?
- Find the schoolhouse. Why do you think the boys are outside?

Talk about it

1. Why do the boys at the end of the line go faster than the boys at the center?
2. How is your arm in a throw like the line of boys? Which part of your body is like the boy at the very end?

3. Why might the game be safer on soft grass than on a hard schoolyard?

Safety first. Warm up with arm circles and easy tosses first. Throw only a soft ball or rolled-up socks, outdoors or in a large room with nothing breakable nearby. Make sure no one is standing in the throwing lane. If your shoulder or elbow hurts, stop and tell a parent.

PROJECT

Adding Links to the Chain

You will throw a soft ball four ways, adding one link of the kinetic chain each time, and measure the distance of every throw. Your data will show how much each link adds.

You will need

- A soft ball, foam ball or tennis ball (outdoors) or rolled-up socks (indoors)
- A tape measure
- Masking tape or chalk to mark a throwing line
- A chair
- A partner to mark landing spots, and the scorebook

Steps

1. Mark a throwing line. Warm up with ten easy tosses.
2. **Predict.** Write how far you think each of the four kinds of throw will go.
3. **Throw 1, arm only:** sit on a chair at the line with your back against it. Throw five times. Your partner marks where each throw first lands, and you measure it.
4. **Throw 2, add the trunk:** stand with feet together and turn your shoulders as you throw. Five throws.
5. **Throw 3, add the step:** start sideways to the target, step toward it with the foot opposite your throwing arm, and throw. Five throws.
6. **Throw 4, the whole chain:** sideways start, step, turn your hips, then your shoulders, let your elbow lead and snap your wrist, and follow through across your body. Five throws.
7. Find the average of each set of five: add them up and divide by 5.
8. Make a bar graph of your four averages. How much did each link add?
9. Watch a partner do throw 4 and describe the order you see, from feet to fingers.

Tips

- Throw at the same height and angle each time so that only one thing changes.
- If a throw slips out of your hand, mark it as a slip and throw again.

Check your work

- ☐ I measured five throws of each kind and found the averages.
- ☐ My graph shows which link added the most distance.
- ☐ I can say the order of the kinetic chain from feet to fingers.

SCOREBOOK

1. Draw a stick figure throwing, in four frames: step, hip turn, shoulder turn, release. Number the body parts in the order they move.
2. Record your throwing table and bar graph.
3. Write two other sports skills that use the kinetic chain and name the first and last link in each.

From history. Homer first drew *Snap the Whip* as a wood engraving for *Harper's Weekly* in 1873, so thousands of American families saw it in their newspaper. He had worked for that magazine as an artist during the Civil War.

COMMON MISTAKES

- Throwing with only the arm, so the big muscles of the legs and trunk do no work.
- Turning everything at once instead of in order. The chain is a ripple, not a block.
- Stopping the arm right after release. A full follow-through protects the shoulder.

Make it a game • Order of the Whip. Write the six links of a good throw on slips of paper: step, hips, trunk, shoulder, elbow, wrist. Shuffle them, then race a one-minute timer to lay them in order from memory of the lesson. Then act out the throw slowly, in order, without a ball. Beat your time on the second round.

1.4 PRACTICE MAKES PROGRESS

OBJECTIVES

- Explain the difference between just playing and deliberate practice.
- Plan a short practice with one goal, quick feedback and many careful repetitions.
- Measure a skill before and after a week of practice and graph the change.

Warm-up. Toss a rolled-up pair of socks into a bucket or laundry basket from 3 meters, ten times. Count your makes and write the number down. Now guess: if you practice for ten minutes a day for five days, how many will you make next week?

WATCH

Deliberate Practice: Achieve Mastery in Anything

Sprouts • 6:04

<https://www.youtube.com/watch?v=1-sjUoGO250>

WHEN TO WATCH

After the story. This sketch animation explains the habits of deliberate practice; list them in your scorebook as you watch.

BACKUP VIDEO

The New Science of Expertise: Anders Ericsson

Rotman School of Management • 3:33

<https://www.youtube.com/watch?v=1feChwxfoY>

For older students: Anders Ericsson himself, speaking to university students about his research.

KEY TERMS

deliberate practice

Practice with one clear goal, full attention, quick feedback and many repetitions, done just beyond what you can already do easily.

feedback

Information about how a try went: where the ball landed, what a coach saw, or what a video shows.

repetition

Doing the same movement again and again, carefully, until it becomes smooth and automatic.

consistency

Doing something the same way every time, so that results land close together.

CORE IDEAS

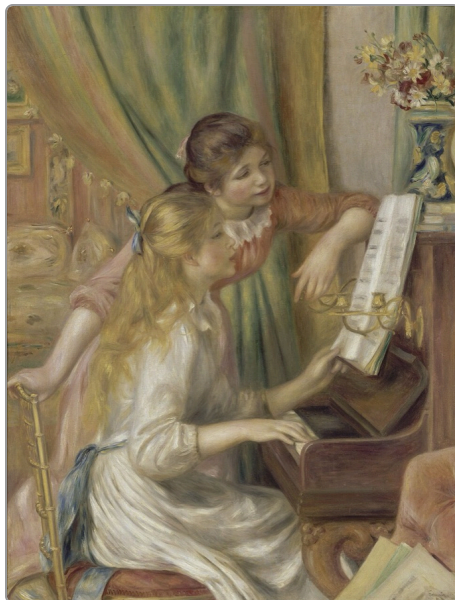
The story. A Swedish scientist named K. Anders Ericsson and two German fellow researchers, Ralf Krampe and Clemens Tesch-Römer, studied young violinists at a famous music school in West Berlin. They wanted to know why some young violinists became excellent while others, just as eager, became only good. They asked the students to keep diaries of how they spent every hour of the week and to remember how much they had practiced at every age. Their report, published in 1993, became one of the best-known studies of how people get better at anything, from music to sport.

How they figured it out. The best violinists were not simply the ones who loved music most or played for fun the most. They were the ones who had spent the most hours in **deliberate practice**: working alone, with full attention, on one hard thing at a time, checking the result and trying again. By the age of eighteen the best players had practiced alone far more hours than the students who were training to be music teachers. Ericsson later found the same pattern in chess, sport and many other skills. Careful practice, more than talent alone, was what made the difference.

The physics. Every time you repeat a movement carefully, your brain and nerves strengthen the pathway for that movement, so it becomes smoother and more automatic. That shows up as **consistency**. A beginner's tosses land all over the place. After good practice, the tosses land close together. You can measure that! Write down where every toss lands, and you will see the spread get smaller as you improve. Careless practice builds careless habits just as surely, so the rule is not "practice makes perfect" but "practice makes permanent." Only good practice makes progress.

On the field. Good athletes practice with a plan: one goal for each session ("keep my elbow up"), quick feedback (a coach, a target or a video), and many careful repetitions, followed by rest. Short practices on many days usually work better than one very long practice. And they keep honest records, so they can see real progress instead of guessing. Whatever skill you choose in this course, you can use the same plan.

PICTURE STUDY



Young Girls at the Piano, Pierre-Auguste Renoir, 1892 · Oil on canvas · Musée d'Orsay, Paris

Image: [Wikimedia Commons](#), public domain

Renoir painted this scene of two girls practicing together several times. The French government bought one version in 1892 for the national museums, and it now hangs in Paris. Music practice and sports practice follow the same rules: one goal, full attention, many careful repetitions.

Look closely

- Where are the seated girl's eyes looking? Where are her hands?
- What is the standing girl doing? How could she help her friend practice?
- Look at the faces. Are the girls rushing, or are they paying close attention?

Talk about it

1. What kind of feedback could the standing girl give? What kind of feedback can a partner give you in sport?
2. Is this girl playing for fun or practicing? How can you tell? Can it be both?
3. What is one skill you would like to practice this way, and what would your one goal be?

Safety first. Use a soft ball or rolled-up socks indoors and clear the area around the target. Keep practices short, about 10 minutes, and stop if your arm gets sore.

PROJECT

A Five-Day Practice Experiment

You will measure a tossing skill, practice it deliberately for five days, and measure it again. You will record not just how many you make but how close your misses land, so you can see your consistency improve.

You will need

- A bucket, small laundry basket or box as a target
- Rolled-up socks or a soft ball
- Masking tape for a throwing line 3 meters from the target
- A tape measure
- The scorebook

Steps

1. **Before test:** stand behind the line and make 20 underhand tosses. For each toss, record “in” or measure how far the miss landed from the target (in centimeters).
2. Count your makes. Find the average miss distance of your misses.
3. **Plan:** choose one thing to work on (for example, “same swing every time,” “eyes on the front of the target,” or “follow through toward the target”). Write it in the scorebook.
4. Practice for 10 minutes a day for five days. Each day, toss in sets of 10. After each set, check: did I do my one thing? Write one sentence of feedback.
5. Ask a partner to watch once during the week and tell you one thing they see.
6. **After test:** on day six, make 20 tosses exactly as in the before test, and record them the same way.
7. Compare your makes and your average miss distance before and after. Make a bar graph.
8. Write a paragraph: Did you improve? Which part of your plan helped most?

Tips

- Do not change the distance or the ball during the week, or the test will not be fair.
- Rest between sets. Tired practice builds sloppy habits.

Check your work

- ☐ I recorded 20 tosses before and 20 after, the same way.
- ☐ I practiced with one clear goal and wrote feedback every day.
- ☐ I graphed my results and explained what helped.

SCOREBOOK

1. Draw the target from above and put a dot for every toss in your before test. Draw it again for your after test. Are the dots closer together?
2. Copy your daily practice log: date, sets, makes, and your one sentence of feedback.
3. Write your own “recipe” for a good practice in four steps.

From history. Ericsson’s research is sometimes boiled down to a “10,000-hour rule,” but he said that was a misunderstanding. There is no special number of hours. What matters is the kind of practice, done well, over time.

COMMON MISTAKES

- Changing several things at once. Work on one thing at a time so you know what helped.
- Only counting makes. How close the misses land shows your progress too.
- Practicing for a very long time when tired. Short, focused practices work better.

Make it a game • Coach for a Day. Be the coach and plan a three-minute practice for your parent on any simple skill, such as tossing a balloon into a bucket. Give one goal, one quick piece of feedback after each try, and many careful repeats. Your parent keeps score. Afterward, name the feedback that helped most.

Scripture. “And whatsoever ye do, do it heartily, as to the Lord, and not unto men;” (Colossians 3:23, KJV)

Deliberate practice means doing ordinary work with your whole heart. That is how Paul tells Christians to do everything.

UNIT 1

YOUR AMAZING BODY

Before you learn to bowl, serve, putt, pass, throw or kick, you need to know the machine that does all of those things: your own body. In this unit you will discover that your bones and joints work like levers, the same simple machines that lift heavy loads and move things fast. You will learn where your center of gravity is, why a tightrope walker carries a long pole, and why bending your knees makes you harder to knock over.

Then you will learn the secret of every powerful throw, swing and kick: the kinetic chain, which passes speed from the legs to the hips to the shoulder to the hand like the crack of a whip. Last, you will learn how practice really works, and why ten careful tries teach more than fifty careless ones. God made your body “fearfully and wonderfully” (Psalm 139:14). This unit will help you see how wonderfully.

PREREQUISITES

- Can measure with a ruler and a tape measure in centimeters
- Can make a tally chart and find an average of a few numbers (or can learn with a parent)
- Has a clear indoor space and, if possible, a yard or park for throwing

MASTERY CHECKLIST

- ☐ I can name the three parts of a lever and find a lever in my arm, my leg and my neck.
- ☐ I can explain what the center of gravity is and show three ways to make myself more stable.
- ☐ I can explain the kinetic chain and show it in a throw, from my feet to my fingers.
- ☐ I can measure a skill, practice it carefully, and measure it again to see my progress.
- ☐ I can keep an honest scorebook with predictions, tallies and what I will change.

OPTIONAL BOOKS AND GAMES FOR THIS UNIT

- **KidsHealth: Your Muscles:** Free. A clear article for children from Nemours KidsHealth on how muscles pull, work in pairs and grow stronger. Fits Lesson 1.1. Ages 8 and up.
- **KidsHealth: Your Bones:** Free. Bones, joints and how they grow, written for children. Fits Lessons 1.1 and 1.2. Ages 8 and up.

Not required. Every project in this unit works without them. School Launch has no ties to these authors, publishers or companies.

LESSONS IN THIS UNIT

1.1 Bones, Joints and Muscles: Levers in Your Body	2 sessions of 45 minutes
1.2 Balance and the Center of Gravity	2 sessions of 45 minutes
1.3 The Kinetic Chain: Your Body's Whip	2 sessions of 45 minutes
1.4 Practice Makes Progress	2 sessions of 45 minutes

UNIT 1 REVIEW

Answer each question in complete sentences. Show your work for the calculation. You may stand up and act out a movement to help you think. The review is worth 50 points.

1. **5 pts**
Name the three parts of a lever, and tell what plays each part when you bend your elbow to lift a ball.
2. **5 pts**
Why do muscles work in pairs?
3. **5 pts**
Your biceps attaches 3 cm from the elbow, and your hand is 30 cm from the elbow. If the muscle moves 1 cm, about how far does the hand move?

4. (5 pts)

What is the center of gravity, and where is it in a person standing straight?

5. (5 pts)

Give three ways to make yourself more stable.

6. (5 pts)

What would happen if Blondin's center of gravity moved to one side of the rope and he did nothing about it? What did his pole do to help?

7. (5 pts)

Put these in the right order for a good throw: elbow, step, wrist, hips, shoulder, trunk.

8. (5 pts)

Explain how the game Snap the Whip shows the kinetic chain.

9. (5 pts)

What would happen if a player threw with only the arm? Give two results.

10. (5 pts)

Describe deliberate practice in your own words, and tell why "practice makes permanent" is a better saying than "practice makes perfect."

ANSWER KEY

1. Fulcrum: the elbow joint. Effort: the biceps muscle pulling on the forearm.
Load: the ball in the hand (and the forearm itself).
2. Muscles can only pull, not push. One muscle pulls a bone one way (the biceps bends the elbow) and its partner pulls it back (the triceps straightens it).
3. $30 \div 3 = 10$, so the hand moves about 10 times as far: about 10 cm.
4. The balance point, where the body's weight acts as if it were all in one spot. In a standing person it is just below the belly button, in the middle of the body.
5. Widen the base of support (feet apart); lower the center of gravity (bend the knees); keep the center of gravity over the middle of the base.
6. He would tip and fall off that side. The long pole made him tip slowly, giving him time to correct, and moving the pole let him shift his balance point back over the rope.
7. Step, hips, trunk, shoulder, elbow, wrist.
8. The boys near the center move slowly and pass their motion along the line; each boy farther out goes faster, and the last boy goes fastest, just as speed passes from the legs and hips out to the hand in a throw.
9. The ball would go slower and shorter, and the shoulder and elbow would have to work too hard, which can strain them.
10. Practice with one clear goal, full attention, quick feedback and many careful repetitions. Whatever you repeat becomes a habit, good or bad, so only careful practice makes progress.

PORTFOLIO PIECE: MY BODY MECHANICS HANDBOOK, PART 1

Make a four-page illustrated handbook titled “How My Body Moves.” Give one page to each lesson: levers (with your cardboard arm drawing), balance (with your balance-lab graph), the kinetic chain (with your throwing graph) and practice (with your before-and-after target drawings). On each page, write a short explanation in your own words and one tip you would give a younger child. Keep the handbook in a folder; you will add to it at the end of the year.

LOOK FOR	WHAT IT MEANS
Accurate ideas	Each page explains its idea correctly, using the words lever, center of gravity, base of support, kinetic chain or deliberate practice.
Real data	Each page includes the student’s own measurements, table or graph from the project.
Clear drawings	Drawings are labeled and help explain the idea.
Helpful tips	Each page has a sensible, safe tip a younger child could follow.

UNIT 2

BOWLING

Bowling is one of the oldest games people play: knock down the pins with a rolling ball. In this unit you will follow the game from the skittles and ninepins of old Europe to the tenpin lanes that the American Bowling Congress standardized in 1895. Then you will learn the body mechanics that good bowlers use: a smooth four-step approach, an arm swing that works like a pendulum, and aiming at a spot on the lane instead of at the pins.

You will build your own bowling alley at home from ten plastic bottles and a soft ball, and you will keep score the way real bowlers do. Bowling rewards patience, steady practice and self-control more than strength, which makes it a sport that a whole family can play together for a lifetime.

PREREQUISITES

- Knows the center of gravity and the base of support (Lesson 1.2)
- Knows that a good movement is a sequence of body parts (Lesson 1.3)
- Can add two-digit numbers for scorekeeping

MASTERY CHECKLIST

- ☐ I can tell how bowling changed from skittles and ninepins to tenpins.
- ☐ I can show the four-step approach and say what the ball does on each step.
- ☐ I can explain why the arm swing works like a pendulum and why “muscling” the ball makes it go off line.
- ☐ I can aim at a spot on the lane, use a simple spare system, and keep a bowling score.
- ☐ I can build and run a safe bottle-bowling alley at home.

OPTIONAL BOOKS AND GAMES FOR THIS UNIT

- **United States Bowling Congress: Youth Bowling**: Free information from bowling's national governing body about youth leagues, coaching and the rules. Useful if your family wants to try a real bowling center after Lesson 2.4. A parent should preview it.

Not required. Every project in this unit works without them. School Launch has no ties to these authors, publishers or companies.

LESSONS IN THIS UNIT

2.1 From Skittles to Tenpins	2 sessions of 45 minutes
2.2 The Four-Step Approach	2 sessions of 45 minutes
2.3 The Pendulum Swing	2 sessions of 45 minutes
2.4 Aim, Spares and a Household Bowling Alley	2 sessions of 45 minutes

UNIT 2 REVIEW

Answer each question in complete sentences. Show your work for the calculation and the score. The review is worth 50 points.

1. **5 pts**
What did the American Bowling Congress do in 1895, and why did it matter?
2. **5 pts**
Why does a bowling pin tip over so easily? Use the words “center of gravity” and “base.”
3. **5 pts**
Name the four steps of the four-step approach and tell where the ball is on each.
4. **5 pts**
Why should the front knee be bent on the slide?

5. (5 pts)

What did Galileo notice about the swinging lamp, and what does change a pendulum's period?

6. (5 pts)

What would happen if a bowler gripped the ball hard and pulled it with the arm muscles?

7. (5 pts)

A ball rolls 6 meters in 3 seconds. How fast is it going?

8. (5 pts)

Why do bowlers aim at the arrows instead of at the pins?

9. (5 pts)

In a game, frame 1 is a spare (7 then 3) and the first ball of frame 2 knocks down 6. What is the score for frame 1?

10. (5 pts)

Why is self-control an important skill in bowling? Give an example.

ANSWER KEY

1. It agreed on one set of rules and standard sizes (lane length, pin size and spacing) for tenpins, so games everywhere were fair and scores could be compared.
2. Its center of gravity is fairly high and its base is small, so a small bump moves the center of gravity outside the base and it falls.
3. Step 1: pushaway (ball moves forward out of the hands). Step 2: ball swings down. Step 3: ball at the top of the backswing. Step 4: slide, ball swings forward and is released.
4. It lowers the center of gravity and keeps it over the sliding foot, so the bowler is balanced at release.
5. Big and small swings took about the same time. The length of the pendulum changes the period most; a longer pendulum swings more slowly.
6. The pull would push the swing sideways and the ball would likely go off line; it would also be harder to repeat.
7. $6 \div 3 = 2$ meters per second.
8. A target close by is easier to hit; if the ball crosses the right spot and rolls straight, it reaches the same place on the pins every time.
9. 10 for the spare plus the next ball, 6, so 16.
10. Getting angry after a bad frame makes the next approach rushed and tense. A calm bowler keeps the same routine and makes the next shot; any sensible example accepted.

PORTFOLIO PIECE: THE FAMILY BOTTLE-BOWLING LEAGUE

Run a small bottle-bowling league with your family for a week: at least three players, three games each. Write and post your alley's official rules (lane length, bottle spacing, foul line, how to reset). Keep every score sheet. At the end, make a league standings chart with each player's average, and a one-page coaching sheet that teaches the four-step approach, the pendulum swing and spot aiming with drawings.

LOOK FOR	WHAT IT MEANS
Fair rules	The alley has clear written standards that were followed for every game.
Accurate scoring	Score sheets are complete and frames with strikes and spares are scored correctly.
Clear coaching sheet	The sheet correctly explains the approach, the pendulum swing and spot aiming with labeled drawings.
Good sportsmanship	The league was run safely and kindly, with every player encouraged.

2.1 FROM SKITTLES TO TENPINS

OBJECTIVES

- Tell the story of bowling from the skittles and ninepins of Europe to American tenpins.
- Explain why rules and standard sizes (lane length, pin size, ball weight) make a game fair.
- Set up a ten-bottle triangle and measure it the way a real pin deck is laid out.

Warm-up. Stand three empty plastic bottles in a row and roll a soft ball at them from 3 meters, five times. Then stand them in a small triangle and roll five more times. Which setup knocked down more bottles? Why might a triangle make the game more interesting?

WATCH

Bowling 101

Bowl Canada · 3:19

<https://www.youtube.com/watch?v=Tbyp-FV7Nu0>

WHEN TO WATCH

After the story. This short video from Canada's bowling association shows that there are two kinds of bowling there, five-pin and ten-pin, each with its own standard ball and pins. Listen for the rules that keep the game fair.

BACKUP VIDEO

International Bowling Museum and Hall of Fame

The Sport of Bowling - USBC · 1:34

<https://www.youtube.com/watch?v=LQGcBKeo7Bg>

A short tour of the International Bowling Museum and Hall of Fame, from ancient bowling to today.

KEY TERMS

skittles

An old European game of knocking down wooden pins with a ball or a flat disk.

ninepins

A game with nine pins set in a diamond, popular in Germany, the Netherlands and early America.

tenpins

Modern bowling, with ten pins set in a triangle at the end of a 60-foot lane.

standard

An agreed size or rule that everyone uses, so games played in different places are fair and can be compared.

CORE IDEAS

The story. People have rolled balls at targets for a very long time. In the Middle Ages, villagers in Germany, the Low Countries and England played skittles and ninepins on hard dirt or wooden boards beside inns and churches. Dutch and German settlers brought ninepins to America in the 1600s and 1700s. In the 1800s, Americans began playing with ten pins set in a triangle instead of nine set in a diamond, and tenpins slowly took over. But every bowling hall had its own rules: different lengths, different pins, different balls. In September 1895, bowlers met in New York City and formed the **American Bowling Congress** to agree on one set of rules for the whole country.

How they figured it out. The bowlers of 1895 knew that a game is only fair when everyone plays on the same field. They agreed on standard measurements, many of which are still used today: 60 feet (about 18.3 meters) from the foul line to the first pin, pins 15 inches (38 centimeters) tall, and ten pins set in a triangle with the centers of neighboring pins 12 inches (30.5 centimeters) apart. Later rules limited the ball to 16 pounds (about 7.3 kilograms). Because of those standards, a score bowled in Ohio means the same thing as a score bowled in Texas.

The physics. Why a triangle? When the ball hits the front pins, they fly back and to the side and knock into the pins behind them. One ball can start a chain of collisions, as each pin passes some of its motion to the next. A pin is shaped to tip easily: it is wide in the middle and narrow at the neck, and its center of gravity is fairly high above a small base, so a small bump moves the center of gravity outside the base and over it goes. Remember Lesson 1.2? A tall object with a small base is easy to tip.

On the field. Today bowling is played in many countries, and children often start with lighter balls and bumpers along the gutters. The standard lane and pin layout mean you can practice anywhere and know how you are improving. At home, ten plastic bottles in the same triangle make a fair, safe practice alley. It will not be 60

feet long, but if you set it up the same way every time, your scores can be compared from week to week.

PICTURE STUDY



Children Playing Nine-Pins, Unknown engraver, 1818 · Hand-colored engraving · From a children's book of games

Image: [Wikimedia Commons](#), public domain

This small hand-colored engraving comes from a children's book of games printed in 1818, when ninepins was still the common form of the game. Children have always loved knocking things down, and grown-ups have always liked teaching them to aim.

Look closely

- Count the pins. How are they arranged: in a row, a diamond or a triangle?
- Look at the crouching girl. Where is her center of gravity, high or low?
- Look at the standing girl. What is she pointing at, and what advice might she be giving?

Talk about it

1. Why would it be harder to knock down pins standing in a single row than pins in a triangle?
2. What would make this game fairer if the two girls wanted to compare their scores tomorrow?
3. What game of rolling or tossing do you play that has no standard rules yet? What rules would you write?

Safety first. Roll balls only, never throw them. Bowl on a hard, clear floor or a smooth outdoor path, away from stairs and furniture, and keep little children and pets out of the lane. The person setting up the bottles stays to the side until the ball has stopped.

PROJECT

Build a Standard Bottle Alley

You will build a home bowling alley with a standard triangle of ten bottles, and test how the spacing changes your scores.

You will need

- Ten empty plastic bottles of the same size (with a little water or sand in each for steadier pins)
- A soft ball, such as a playground ball or a foam ball about the size of a grapefruit
- Masking tape and a tape measure
- The scorebook

Steps

1. Choose a lane at least 4 meters long. Mark a foul line with tape.
2. Draw the triangle on graph paper first: one bottle in front, then 2, then 3, then 4, with the bottles' centers the same distance apart.
3. Mark the triangle on the floor with small tape crosses, 20 centimeters apart (a scaled-down version of the real 12 inches). Number the spots 1 to 10 the way real pins are numbered: 1 in front, 2 and 3 behind, 4, 5 and 6 next, and 7, 8, 9, 10 in the back row.
4. **Predict.** If you move the bottles closer together (15 cm) or farther apart (30 cm), will you knock down more or fewer?
5. Roll ten balls at the 20 cm triangle, resetting all ten bottles after each roll. Record how many fall each time.
6. Repeat with the bottles 15 cm apart and then 30 cm apart.
7. Find the average for each spacing and make a bar graph.
8. Choose the spacing your family will use for the rest of the unit, and write it on a card as your alley's official standard.

Tips

- Fill each bottle with the same amount of water so they are equally heavy.

- Use the tape crosses so you reset the bottles in exactly the same places.

Check your work

- ☐ I built a ten-bottle triangle and numbered the pins correctly.
- ☐ I tested three spacings, ten rolls each, and graphed the averages.
- ☐ I wrote my alley's official standard.

SCOREBOOK

1. Draw the pin triangle from above and number the pins 1 to 10.
2. Make a time line: skittles in old Europe, ninepins in early America, tenpins in the 1800s, the American Bowling Congress in 1895, today.
3. Record your spacing test table and graph.

From history. Before machines, “pinboys” stood at the end of the lanes and set the pins up by hand after every ball. Automatic pinsetters spread through American bowling centers in the 1950s, which made bowling faster and helped make it a popular family sport.

COMMON MISTAKES

- Setting the bottles by eye instead of on marks, so the test is not fair.
- Throwing the ball instead of rolling it. Bowling is a rolling game.

Make it a game • Skittles Rewind. Race your parent to tell the story of bowling in order: skittles, ninepins, tenpins. Put three bottles or cups out for each stage and name one fact as you knock one over with a soft roll. Then explain in one sentence why a standard lane and pin size make the game fair.

2.2 THE FOUR-STEP APPROACH

OBJECTIVES

- Show the four-step approach and match each step to what the ball is doing.
- Explain how walking into the shot adds speed and how timing keeps the body balanced.
- Practice the approach with a soft ball and finish in a balanced slide position.

Warm-up. Stand still at a line and roll a soft ball at a bottle 4 meters away, five times. Then start four steps back, walk smoothly up to the line, and roll again five times. Which way felt more powerful? Which way was more accurate?

WATCH

Four Step Approach Explained - Important Keys for Perfect Footwork

KR Strikeforce • 3:23

<https://www.youtube.com/watch?v=0cQ6BsK7Cco>

WHEN TO WATCH

After “the physics.” Count the steps out loud with the bowler.

KEY TERMS

approach

The steps a bowler takes before releasing the ball, and also the area of floor behind the foul line where those steps are taken.

pushaway

Moving the ball forward and slightly down out of the hands on the first step, to start the swing.

timing

Matching the ball’s swing to the steps, so the ball comes forward just as the last step slides.

slide

The last step, in which the front foot glides to a stop with the knee bent, so the bowler is balanced at release.

CORE IDEAS

The story. Marion Ladewig of Grand Rapids, Michigan, was named the best woman bowler of the year a record nine times between 1950 and 1963. Bowlers of her day, like bowlers today, learned that power and accuracy start with the feet. A smooth, repeatable approach lets a bowler deliver the ball the same way frame after frame,

game after game. Coaches have taught the **four-step approach** to beginners for generations because it is simple to learn and easy to time.

How they figured it out. Coaches noticed that bowlers who stood still had to throw the ball with the arm alone, and bowlers who ran up wildly lost their balance. The best bowlers walked: four smooth steps, each a little faster than the last, with the ball swinging in time. They watched where the ball was on each step. Step 1: the ball is pushed away. Step 2: it swings down past the leg. Step 3: it reaches the top of the backswing. Step 4: the front foot slides as the ball swings forward and is released. When the ball and the feet arrive together, the shot is smooth.

The physics. Walking gives your body **momentum**. When you release the ball, it keeps the forward speed of your body plus the speed of your arm swing, so you do not need to force the ball. The slide on the last step lets your body slow down gently, and the bent front knee lowers your center of gravity and keeps it over your sliding foot, so you are balanced as the ball leaves your hand. If the timing is off, for example if the ball arrives late, your body is already stopped and your arm has to pull the ball through on its own.

On the field. Good bowlers practice the approach without a ball, counting “one, two, three, slide.” They finish each shot in a balanced pose, holding it until the ball reaches the pins. Coaches call this “posting” the shot. If you can hold your finish without wobbling, your balance was good. Right-handed bowlers start with the right foot on step 1 and slide on the left foot; left-handers do the opposite.

PICTURE STUDY



A Game of Nine-Pin Bowling, Unknown photographer (Fortepan collection), 1916 · Photograph · Hungary

Image: [Wikimedia Commons](#), public domain

This photograph from a Hungarian archive shows an outdoor nine-pin lane beside an inn, a common sight in Central Europe a hundred years ago. It was taken in 1916. One man is about to roll while his friends sit and watch.

Look closely

- Find the bowler. Is he standing still or stepping into the shot?
- Look at his knees and back. Is his center of gravity high or low?
- Look at his arm. Where is the ball in its swing?
- Find the narrow wooden lane. Why does a bowler need to be accurate here?

Talk about it

1. Which of the four steps do you think the bowler is on? Why?
2. If he lost his balance just as he released the ball, what would happen to the shot?
3. Bowling was often played beside an inn, with friends watching. How can a bowler stay calm and keep his routine when people are watching?

Safety first. Wear shoes with good grip, or bare feet on carpet; never practice the approach in socks on a slick floor. Clear the approach area of toys and rugs that could slide. Walk, do not run. Roll a soft ball only.

PROJECT

Count, Swing, Slide

You will learn the four-step approach in stages, film or watch it, and test whether it makes your rolls straighter and more consistent than a standing roll.

You will need

- Your bottle alley from Lesson 2.1
- A soft ball
- Masking tape to mark a starting spot about four steps behind the foul line
- A phone camera or a partner to watch
- The scorebook

Steps

1. **Find your start.** Stand at the foul line with your back to the pins. Take four and a half normal walking steps away from the line and mark that spot with tape.
2. **Feet only.** Without a ball, walk the four steps toward the line, counting “one, two, three, slide.” Make each step a little faster than the last. Do this ten times.
3. **Add the swing.** Hold the soft ball. On step 1, push it forward; on step 2, let it swing down; on step 3, let it swing back; on step 4, slide and let it swing forward and roll. Practice five times without bottles.
4. **Finish and hold.** After each roll, hold your finish for a count of three: front knee bent, arm pointing at the target. A partner tells you if you wobbled.
5. **Predict.** Will the four-step roll knock down more bottles than a standing roll?
6. **Test.** Roll ten balls standing still at the line, then ten with the four-step approach. Reset all bottles each time and record the pins knocked down.
7. If you can, film three approaches from the side and watch them in slow motion. Is the ball at the top of the backswing on step 3?
8. Compare the averages and write which part of the approach you most need to practice.

Tips

- Keep your eyes on a spot in front of the bottles, not on your feet.
- Short, smooth steps are better than long, fast ones.

Check your work

- ☐ I can walk the four steps with correct timing.
- ☐ I held a balanced finish on most rolls.
- ☐ I compared standing rolls and approach rolls with ten tries each.

SCOREBOOK

1. Draw four stick figures, one for each step, and draw where the ball is on each step.
2. Record your standing and approach scores in a table and find the averages.
3. Write three things you checked in your film or that your partner saw.

From history. The Women's International Bowling Congress was founded in 1916, and for many years men and women had separate national organizations. In 2005 they joined with youth bowling groups to form the United States Bowling Congress, which keeps the rules today.

COMMON MISTAKES

- Rushing the last step, so the ball arrives late and the arm has to pull it.
- Standing up straight at release instead of bending the front knee.
- Looking down at the feet instead of at the target.

Make it a game • Step Call-Out. Walk the four-step approach in the hallway while your parent calls a step number at random. Freeze on that step and say what the ball is doing right then. Wrong answers, or a wobble, give your parent the point. Play to five. Parents may call out the pushaway or the slide to keep you sharp.

2.3 THE PENDULUM SWING

OBJECTIVES

- Describe what a pendulum is and what changes its swing.
- Explain why a bowler lets the ball swing like a pendulum instead of forcing it.
- Measure how backswing height changes ball speed.

Warm-up. Tie a small object (a washer, a key or a sock with a coin inside) to a 50 cm string and let it swing. Count how many swings it makes in 15 seconds. Now pull it back farther and count again. Did a bigger swing take longer?

WATCH

Proper Bowling Arm Swing. | USBC Bowling Academy

National Bowling Academy • 2:23

<https://www.youtube.com/watch?v=BkS5586-Xuk>

WHEN TO WATCH

After the physics paragraph. Watch the bowler's arm: is it pulling the ball, or letting it swing?

KEY TERMS

pendulum

A weight that hangs from a fixed point and swings freely back and forth.

period

The time a pendulum takes to swing out and back once.

backswing

How far back and up the ball swings behind the bowler before it comes forward.

muscling

Forcing the ball with the arm muscles instead of letting it swing; it usually pulls the ball off line.

CORE IDEAS

The story. One day around 1582, a young medical student named Galileo Galilei was sitting in the great cathedral of Pisa, in Italy. A lamp hanging from the ceiling on a long chain was swinging gently in the air. Galileo timed the swings against his own pulse and noticed something odd: whether the lamp swung a long way or only a little, each swing seemed to take the same time. That story was written down later by

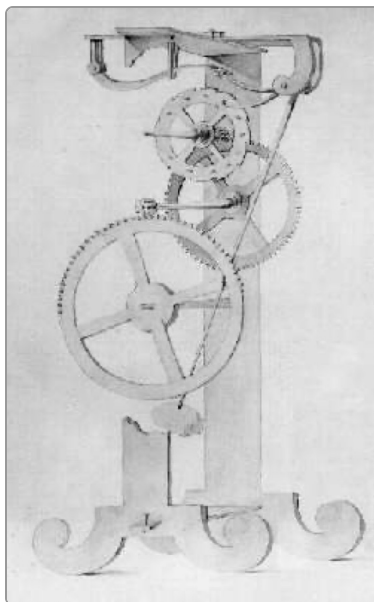
his student Vincenzo Viviani. Galileo kept studying pendulums for the rest of his life, and near the end of it he designed a clock that used a pendulum to keep time.

How they figured it out. Galileo tested pendulums with different weights and different lengths. He found that the time of a swing does not depend on how heavy the weight is, and it hardly depends on how wide the swing is when the swing is small. It depends mainly on the **length** of the string: a longer pendulum swings more slowly. A pendulum about one meter long takes about two seconds to swing out and back. The Dutch scientist Christiaan Huygens built the first working pendulum clock in 1656, and pendulum clocks were the best timekeepers in the world for nearly three hundred years.

The physics. Your arm holding a bowling ball is a pendulum: the shoulder is the pivot, the arm is the string, and the ball is the weight. When you lift the ball higher in the backswing, gravity has farther to pull it down, so it is moving faster at the bottom. That means a higher backswing gives a faster ball without any extra muscle. Because a free pendulum swings in a straight line, a relaxed arm sends the ball straight toward the target. When you grip hard and pull with your muscles, you add a push that can turn the swing sideways, and the ball goes off line.

On the field. Bowling coaches tell players to “let the ball swing.” They teach a relaxed grip, a straight arm and a pushaway that sets the height of the backswing. The bowler controls speed mostly by the height of the pushaway and backswing and by the pace of the steps, not by throwing harder. The same idea shows up in golf putting (Unit 4) and the underhand volleyball serve (Unit 5): a smooth pendulum is easier to repeat than a hard push.

PICTURE STUDY



Galileo's Pendulum Clock, Drawing attributed to Vincenzo Viviani, About 1659, from Galileo's design of 1641 · Drawing · Florence, Italy

Image: [Wikimedia Commons](#), public domain

In 1641, when he was old and blind, Galileo described to his son Vincenzo and his student Vincenzo Viviani a clock that would be kept in time by a pendulum. It was never finished in his lifetime. This drawing of the design was made years later.

Look closely

- Find the large wheels and the small wheels. What do you think turns them?
- Find the pendulum. Where is its pivot, the point it swings from?
- Look for the part where the pendulum touches the gears. How might it let the wheels turn one tooth at a time?

Talk about it

1. Why would a pendulum make a good timekeeper?
2. How is your bowling arm like the pendulum in this drawing? What is the pivot?
3. Galileo started with a swinging lamp in a church. What everyday thing could you watch carefully to learn something new?

Safety first. Swing the string pendulum away from faces and lamps. For the rolling test, use a soft ball and keep the lane clear. Let the ball swing gently; do not swing so high that you lose your balance.

PROJECT

Pendulums and Ball Speed

First you will test what changes a pendulum's period. Then you will test whether a higher backswing makes your bowling roll faster.

You will need

- String, a small weight (washer, keys or a sock with coins) and tape to hang it from a table edge
- A stopwatch or phone timer and a tape measure
- Your bottle alley and soft ball
- A partner and the scorebook

Steps

1. Hang the weight from a 25 cm string. Time 10 full swings and divide by 10 to find the period. Repeat with 50 cm and 100 cm strings.
2. With the 50 cm string, try a small swing and a large swing. Does the period change much?
3. Add a second weight to the same string. Does the period change?
4. Make a table of all your results and write which change mattered most.
5. **Predict.** Will a higher backswing make your bowling roll reach the bottles faster?
6. Mark a start line 5 meters from the head bottle. Roll five balls with a low backswing (about knee high) while your partner times each roll from release until the ball reaches the bottles.
7. Roll five balls with a higher backswing (about hip high), keeping your arm relaxed. Time them the same way.
8. Find the average time for each and work out the speed (5 meters $\div$ time). Write what you discovered.

Tips

- Start the stopwatch exactly when the ball leaves your hand; practice a few times first.

- Keep your arm straight and relaxed, like a rope, not a stick.

Check your work

- ☐ I found that string length changes the period most.
- ☐ I timed five low and five high backswing rolls.
- ☐ I calculated two speeds and compared them.

SCOREBOOK

1. Draw your arm as a pendulum: label the pivot (shoulder), the string (arm) and the weight (ball).
2. Record your pendulum table: length, size of swing, weight, period.
3. Record your rolling speeds and write one sentence comparing them.

From history. Galileo is honored as one of the founders of modern science. He wrote that the book of nature is written in the language of mathematics, and he believed the Bible and the study of nature, rightly understood, could not contradict each other, because both come from God.

WORKED EXAMPLES

Example 1. Your string pendulum makes 10 full swings (out and back) in 14 seconds. What is its period?

Show solution

1. Period = total time $\div$ number of swings.
2. 14 seconds $\div$ 10 swings = 1.4 seconds.

Answer: 1.4 seconds for each full swing.

Example 2. A soft ball rolls 5 meters to the bottles in 2.5 seconds with a low backswing and in 2.0 seconds with a high backswing. How fast was each roll?

Show solution

1. Speed = distance $\div$ time.
2. Low backswing: 5 m $\div$ 2.5 s = 2.0 meters per second.
3. High backswing: 5 m $\div$ 2.0 s = 2.5 meters per second.

Answer: 2.0 m/s and 2.5 m/s. The higher backswing gave a faster ball.

COMMON MISTAKES

- Gripping the ball tightly and pulling it, so it curves off line.
- Timing only one swing. Time ten and divide, for a more accurate answer.

Make it a game • Pendulum Prediction. Hang a key or a small weight on a string from a chair back. Before each swing, predict whether the period will change if you make the string shorter or the weight heavier. Time ten swings with a parent counting, then check your guess. Score a point for each correct prediction, and explain why bowlers do not muscle the ball.

2.4 AIM, SPARES AND A HOUSEHOLD BOWLING ALLEY

OBJECTIVES

- Explain spot bowling: aiming at a mark on the lane instead of at the pins.
- Use a simple spare system to choose where to stand and where to aim for leftover pins.
- Bowl and score a full ten-frame game on a home bottle alley.

Warm-up. Roll five balls at your bottle triangle while looking at the bottles. Then put a coin on the floor about one meter in front of you, in line with the front bottle, and roll five more while looking only at the coin. Which way was more accurate?

WATCH

[Using the 3-6-9 Spare System Moving Right | USBC Bowling Academy](https://www.youtube.com/watch?v=9VUCLtS_Srl)

[National Bowling Academy](https://www.youtube.com/watch?v=9VUCLtS_Srl) • 2:15

https://www.youtube.com/watch?v=9VUCLtS_Srl

WHEN TO WATCH

After “on the field.” Watch how the bowler moves to a new spot for each spare.

KEY TERMS

spot bowling

Aiming at a mark close to you on the lane instead of at the pins far away.

pocket

The best place for the ball to hit the pins for a strike: between the 1 and 3 pins for a right-handed bowler, or the 1 and 2 pins for a left-handed bowler.

spare

Knocking down all ten pins with two balls in one frame.

frame

One turn in bowling, with up to two balls. A game has ten frames.

CORE IDEAS

The story. Look closely at a real bowling lane and you will see a set of small arrows set into the wood about 12 to 16 feet (4 to 5 meters) past the foul line. Lane makers added these target arrows in the 20th century because good bowlers had discovered something: it is much easier to hit a small target that is close than one that is 60

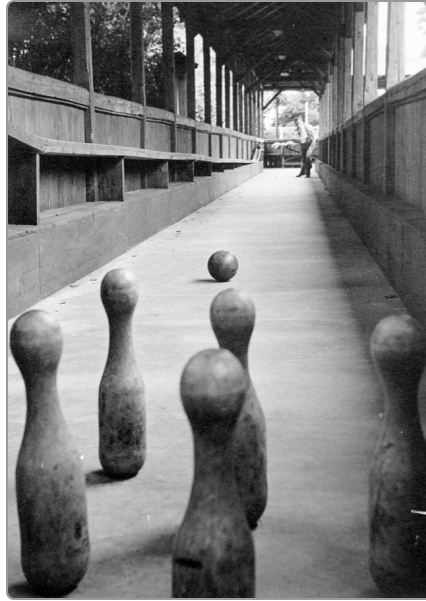
feet away. Today nearly every coach teaches beginners to aim at the arrows, not at the pins.

How they figured it out. If you aim at something far away, a tiny mistake in the angle of your arm grows bigger and bigger as the ball travels. Bowlers found that if they rolled the ball over a chosen arrow, and the ball rolled straight, it would arrive in the same place on the pins every time. Then they worked out a system for spares. A lane is made of 39 boards. By moving their starting spot a few boards left or right and keeping the same target arrow, bowlers could aim the ball at different pins. One common method, the 3-6-9 spare system, moves the feet 3, 6 or 9 boards depending on which pin is left standing.

The physics. A ball rolling on a smooth lane keeps going in a straight line unless something pushes it sideways (that is Newton's first law). So the ball's path is set by two points: where it is released and where it crosses the target. Pick those two points well and the third point, where it hits the pins, takes care of itself. Hitting the pocket at an angle sends the head pin back into the pins behind it, which knock down still others: a chain reaction of collisions, each pin passing some of its momentum to the next.

On the field. Strong bowlers are not those who knock down all ten pins every time; they are the ones who make their spares. Missing a spare costs more points than most beginners realize, because a spare earns a bonus. Good bowlers learn a simple spare system, practice the most common leftover pins, and stay patient and calm after a bad frame. Self-control is a real bowling skill.

PICTURE STUDY



Down the Lane, Unknown photographer (Fortepan collection), 1936 · Photograph · Hungary

Image: [Wikimedia Commons](#), public domain

This photographer set up the camera at the far end of a covered bowling lane, behind the pins, so we see the ball coming straight at us. It is the bowler's view turned around.

Look closely

- Find the ball. Is it rolling down the middle of the lane or toward one side?
- Look at how long and narrow the lane is. How small a mistake at the start would send the ball off to the side by the time it arrives?
- Count the pins you can see. Which ones will the ball hit first?

Talk about it

1. Why is it easier to aim at a spot near you than at pins far away?
2. If the ball hits the front pin straight on, where do you think that pin will go?
What if it hits it from an angle?
3. How would you keep calm and try again after a ball rolled into the gutter?

Safety first. Roll, never throw. Keep everyone behind the bowler or well to the side of the lane, and wait until the ball has stopped before resetting bottles. Keep the floor clear and dry.

PROJECT

A Ten-Frame Bottle Bowling Game

You will add a target spot to your bottle alley, learn to keep a bowling score, and bowl two full games: one aiming at the bottles and one aiming at the spot.

You will need

- Your bottle alley and soft ball
- Masking tape for a target spot and for “boards” (lines) across the foul line
- A printed or hand-drawn ten-frame score sheet
- The scorebook

Steps

1. Put a small tape X on the floor about one-quarter of the way down your lane, in line with the head bottle. This is your target arrow.
2. Along the foul line, mark seven short tape lines 5 cm apart. These are your “boards” for moving your feet.
3. Learn the scoring: a frame has up to two balls. If you knock down all ten bottles with the first ball (a strike), add the next two balls as a bonus. If you need both balls (a spare), add the next one ball as a bonus. Otherwise, score the bottles knocked down.
4. **Game 1:** bowl ten frames looking at the bottles. Keep score.
5. **Game 2:** bowl ten frames looking only at the tape X. Keep score.
6. Spare practice: set up just the right corner bottle (10 for right-handers, 7 for left-handers). Move your feet three marks to the opposite side, aim at the X, and roll five times. Record hits.
7. Compare the two game scores and your spare hits. Write which aiming method you will use and why.

Tips

- Keep your eyes on the X until the ball rolls over it.
- Use the same starting spot and four-step approach for every first ball.

Check your work

- ☐ I bowled two ten-frame games and scored them correctly.
- ☐ I practiced a corner spare with the moving-feet system.
- ☐ I compared the two aiming methods with my scores.

SCOREBOOK

1. Draw your lane from above with the foul line, the boards, the target X and the bottles. Draw the ball's path for a first ball and for a corner spare.
2. Copy both score sheets.
3. Write about a frame that went badly and what you did to stay calm for the next one.

From history. Bowling scores used to be added up by hand with a pencil on a paper sheet, and every bowler learned to do it. Automatic scoring screens became common in the 1970s and 1980s. Learning to score by hand still helps you understand why spares matter so much.

COMMON MISTAKES

- Looking up at the bottles during the swing instead of at the target.
- Moving the target instead of moving the feet for spares.
- Adding bonuses wrongly. Check each frame twice.

Make it a game • Spare Detective. Set up ten bottles in a triangle and let your parent secretly knock down some. Study the leftover pins for ten seconds, then tell your parent where to stand, what mark to aim at, and why spot bowling beats aiming at pins. Switch roles. Award a point for each full, correct explanation.

Scripture. “He that is slow to anger is better than the mighty; and he that ruleth his spirit than he that taketh a city.” (Proverbs 16:32, KJV)

A bowler who stays calm after a bad frame plays better than one who loses his temper. Ruling your spirit is a strength.

UNIT 2

BOWLING

Bowling is one of the oldest games people play: knock down the pins with a rolling ball. In this unit you will follow the game from the skittles and ninepins of old Europe to the tenpin lanes that the American Bowling Congress standardized in 1895. Then you will learn the body mechanics that good bowlers use: a smooth four-step approach, an arm swing that works like a pendulum, and aiming at a spot on the lane instead of at the pins.

You will build your own bowling alley at home from ten plastic bottles and a soft ball, and you will keep score the way real bowlers do. Bowling rewards patience, steady practice and self-control more than strength, which makes it a sport that a whole family can play together for a lifetime.

PREREQUISITES

- Knows the center of gravity and the base of support (Lesson 1.2)
- Knows that a good movement is a sequence of body parts (Lesson 1.3)
- Can add two-digit numbers for scorekeeping

MASTERY CHECKLIST

- ☐ I can tell how bowling changed from skittles and ninepins to tenpins.
- ☐ I can show the four-step approach and say what the ball does on each step.
- ☐ I can explain why the arm swing works like a pendulum and why “muscling” the ball makes it go off line.
- ☐ I can aim at a spot on the lane, use a simple spare system, and keep a bowling score.
- ☐ I can build and run a safe bottle-bowling alley at home.

OPTIONAL BOOKS AND GAMES FOR THIS UNIT

- **United States Bowling Congress: Youth Bowling**: Free information from bowling's national governing body about youth leagues, coaching and the rules. Useful if your family wants to try a real bowling center after Lesson 2.4. A parent should preview it.

Not required. Every project in this unit works without them. School Launch has no ties to these authors, publishers or companies.

LESSONS IN THIS UNIT

2.1 From Skittles to Tenpins	2 sessions of 45 minutes
2.2 The Four-Step Approach	2 sessions of 45 minutes
2.3 The Pendulum Swing	2 sessions of 45 minutes
2.4 Aim, Spares and a Household Bowling Alley	2 sessions of 45 minutes

UNIT 2 REVIEW

Answer each question in complete sentences. Show your work for the calculation and the score. The review is worth 50 points.

1. **5 pts**
What did the American Bowling Congress do in 1895, and why did it matter?
2. **5 pts**
Why does a bowling pin tip over so easily? Use the words “center of gravity” and “base.”
3. **5 pts**
Name the four steps of the four-step approach and tell where the ball is on each.
4. **5 pts**
Why should the front knee be bent on the slide?

5. (5 pts)

What did Galileo notice about the swinging lamp, and what does change a pendulum's period?

6. (5 pts)

What would happen if a bowler gripped the ball hard and pulled it with the arm muscles?

7. (5 pts)

A ball rolls 6 meters in 3 seconds. How fast is it going?

8. (5 pts)

Why do bowlers aim at the arrows instead of at the pins?

9. (5 pts)

In a game, frame 1 is a spare (7 then 3) and the first ball of frame 2 knocks down 6. What is the score for frame 1?

10. (5 pts)

Why is self-control an important skill in bowling? Give an example.

ANSWER KEY

1. It agreed on one set of rules and standard sizes (lane length, pin size and spacing) for tenpins, so games everywhere were fair and scores could be compared.
2. Its center of gravity is fairly high and its base is small, so a small bump moves the center of gravity outside the base and it falls.
3. Step 1: pushaway (ball moves forward out of the hands). Step 2: ball swings down. Step 3: ball at the top of the backswing. Step 4: slide, ball swings forward and is released.
4. It lowers the center of gravity and keeps it over the sliding foot, so the bowler is balanced at release.
5. Big and small swings took about the same time. The length of the pendulum changes the period most; a longer pendulum swings more slowly.
6. The pull would push the swing sideways and the ball would likely go off line; it would also be harder to repeat.
7. $6 \div 3 = 2$ meters per second.
8. A target close by is easier to hit; if the ball crosses the right spot and rolls straight, it reaches the same place on the pins every time.
9. 10 for the spare plus the next ball, 6, so 16.
10. Getting angry after a bad frame makes the next approach rushed and tense. A calm bowler keeps the same routine and makes the next shot; any sensible example accepted.

PORTFOLIO PIECE: THE FAMILY BOTTLE-BOWLING LEAGUE

Run a small bottle-bowling league with your family for a week: at least three players, three games each. Write and post your alley's official rules (lane length, bottle spacing, foul line, how to reset). Keep every score sheet. At the end, make a league standings chart with each player's average, and a one-page coaching sheet that teaches the four-step approach, the pendulum swing and spot aiming with drawings.

LOOK FOR	WHAT IT MEANS
Fair rules	The alley has clear written standards that were followed for every game.
Accurate scoring	Score sheets are complete and frames with strikes and spares are scored correctly.
Clear coaching sheet	The sheet correctly explains the approach, the pendulum swing and spot aiming with labeled drawings.
Good sportsmanship	The league was run safely and kindly, with every player encouraged.

UNIT 3

TENNIS

Tennis began as a game played with the palm of the hand in the courtyards of medieval France and grew into the lawn tennis of the first Wimbledon Championship in 1877. In this unit you will follow that story and then learn the body mechanics every tennis player uses: a ready position and split step that let you react in a fraction of a second, a forehand that swings the racket like a long lever, and a serve that is really an overhead throw.

You will practice with balloons and soft balls indoors, and with a paper-plate or soft racket, so you can learn good form without a court. If your family can visit a public court, a parent can come along and watch you try what you learned.

PREREQUISITES

- Knows the athletic stance and the center of gravity (Lesson 1.2)
- Knows the kinetic chain and the order of a good throw (Lesson 1.3)
- Can measure time with a stopwatch and find an average

MASTERY CHECKLIST

- ☐ I can tell how tennis grew from the jeu de paume to the first Wimbledon in 1877.
- ☐ I can show the ready position and the split step and explain why they make me faster.
- ☐ I can explain how the racket works as a lever and how the angle of the strings sends the ball.
- ☐ I can show that a good serve uses the same kinetic chain as an overhand throw.
- ☐ I can practice tennis skills safely at home with a balloon or a soft ball.

OPTIONAL BOOKS AND GAMES FOR THIS UNIT

- **USTA: Youth Tennis:** Free information from the United States Tennis Association about youth tennis with smaller courts, lower-bouncing balls and shorter rackets, and how to find a program. Fits the whole unit. A parent should preview it.

Not required. Every project in this unit works without them. School Launch has no ties to these authors, publishers or companies.

LESSONS IN THIS UNIT

3.1 From the Jeu de Paume to Wimbledon

2 sessions of 45 minutes

3.2 The Ready Position and the Split Step

2 sessions of 45 minutes

3.3 The Forehand

2 sessions of 45 minutes

3.4 The Serve Is a Throw

2 sessions of 45 minutes

UNIT 3 REVIEW

Answer each question in complete sentences. Show your work for the calculation. You may stand up and show a movement. The review is worth 50 points.

1. **5 pts**

What was the jeu de paume, and how did Major Wingfield change the game in 1874?

2. **5 pts**

What happened at Wimbledon in July 1877, and who won?

3. **5 pts**

Why does a ball hit with a racket go faster than a ball hit with the palm?

4. **5 pts**

Describe the ready position and tell why each part helps.

5. **5 pts**

What would happen if a player did the split step much too early?

6. **5 pts**

Your ruler-drop catches are 14, 18, 16 and 16 cm. What is the average?

7. **5 pts**

What mainly decides where the ball goes after it hits the racket?

8. (5 pts)

Why do players swing from low to high on the forehand?

9. (5 pts)

Name four links of the kinetic chain in a tennis serve, in order.

10. (5 pts)

Why is the toss so important in the serve?

ANSWER KEY

1. The “game of the palm,” a medieval French indoor game first played with the hand and later with rackets. Wingfield patented an outdoor version that could be played on a lawn: lawn tennis.
2. The first Lawn Tennis Championship was held under fixed rules; twenty-two men entered and Spencer Gore won.
3. The racket makes the arm a longer lever, so its far end moves faster for the same turn of the arm, and the strings spring back like a trampoline.
4. Feet shoulder-width apart for a wide base; knees bent for a low center of gravity and springy legs; weight on the balls of the feet to move quickly; racket in front to be ready on either side.
5. The spring from landing would be used up before the opponent hit, so the player would be standing still again and would react late.
6. $14 + 18 + 16 + 16 = 64$; $64 \div 4 = 16$ cm.
7. The angle of the racket face at the moment of contact.
8. It puts topspin on the ball, which makes it dip down into the court, so the player can swing hard and still keep the ball in.
9. Any four in order: legs push up, hips turn, trunk turns, shoulder rotates, elbow straightens, forearm turns over, racket.
10. The whole swing is aimed at the place the ball will be. A toss that is too low, too far back or to the side forces the player to change the swing, and the serve goes wrong.

PORTFOLIO PIECE: A TENNIS COACHING CARD FOR A YOUNGER CHILD

Make a folded coaching card (or a short slideshow) that teaches a younger brother, sister or friend to play balloon tennis. Include four panels: the ready position and split step, the forehand, the toss and serve, and safe balloon-tennis rules. Use your own drawings or photographs of yourself. Then teach the child for 15 minutes and write a short report: what you taught, what was hard for the child, and what you changed in your teaching.

LOOK FOR	WHAT IT MEANS
Correct technique	Each panel shows the skill correctly with the key words (knees bent, contact in front, low to high, toss in front).
Clear pictures	Drawings or photos are labeled and easy for a younger child to follow.
Safety	The card includes sensible safety rules for playing indoors.
Teaching report	The report describes a real lesson honestly and names one change that helped.

3.1 FROM THE JEU DE PAUME TO WIMBLEDON

OBJECTIVES

- Tell how tennis grew from the jeu de paume of France to Major Wingfield's lawn tennis and the first Wimbledon Championship in 1877.
- Explain how the racket changed the game by making the arm a longer lever.
- Compare hitting a balloon with the palm of the hand and with a homemade racket.

Warm-up. Bat a balloon into the air with the palm of your hand and count how many hits you can make without letting it touch the floor. Then tape a paper plate to a ruler or paint stirrer to make a little racket and try again. Which was easier to control? Which hit the balloon higher?

WATCH

The History of Tennis

International Tennis Hall of Fame • 7:53

<https://www.youtube.com/watch?v=PWM6v7XLyeg>

WHEN TO WATCH

After the story. The International Tennis Hall of Fame tells the story from the old indoor game to today. Look for the wooden rackets and the long white clothes of the first players.

KEY TERMS

jeu de paume

French for “game of the palm”: an indoor ball game of medieval France, first played with the hand and later with rackets. It is still played today as real tennis.

lawn tennis

Tennis played outdoors on grass, invented in England in the 1870s.

racket

A handle and a frame strung with a tight net of strings for hitting the ball.

championship

A contest held under fixed rules to decide the best player.

CORE IDEAS

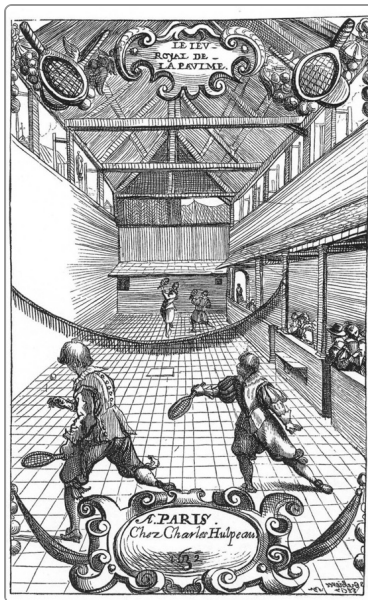
The story. More than eight hundred years ago, people in France began playing a game in which they hit a ball back and forth with the palm of the hand. They called it the *jeu de paume*, the “game of the palm.” It moved into walled indoor courts, and by the 1500s players were using rackets strung with gut. Many people think our word *tennis* comes from the French *tenez!*, “take this!”, which a player called out when he served. In 1874, an English army officer named Major Walter Clopton Wingfield patented an outdoor version that could be played on a lawn. Lawn tennis spread quickly. In July 1877 the All England Croquet and Lawn Tennis Club at Wimbledon, near London, held the first Lawn Tennis Championship. Twenty-two men entered, and Spencer Gore won.

How they figured it out. For the 1877 championship, the club had to write rules everyone would follow. A committee chose a rectangular court instead of Wingfield’s hourglass shape, set the court size, and borrowed the old scoring of the *jeu de paume*: 15, 30, 40 and game. Over the following years, players kept learning what worked. Early players often hit softly and patted the ball over the net. Soon stronger players found they could win by hitting harder, rushing to the net and serving overhand, and the game we know began to take shape.

The physics. A racket makes your arm a longer lever (Lesson 1.1). When you swing, every part of your arm and racket turns together around your shoulder, but the far end of the racket travels the longest path in the same time, so it moves fastest. That is why a ball struck with a racket flies much faster than a ball hit with the palm. The tight strings act like a trampoline: they stretch for a moment and then spring back, sending the ball off again. The racket’s large face also makes it easier to hit the ball squarely than with a hand.

On the field. Beginners today often start with lighter, shorter rackets, softer balls that bounce lower and slower, and smaller courts, so they have time to swing well. The goal is the same as in 1877: keep the ball in play over the net and inside the lines, one more time than your opponent. At home, a balloon and a paper-plate racket are a fine way to learn to watch the ball and meet it in the middle of the strings.

PICTURE STUDY



A Royal Jeu de Paume Court in Paris, Published by Charles Hulpeau, 1632 · Copper engraving · Paris, France

Image: [Wikimedia Commons](#), public domain

This engraving appeared in a French book about the rules of the jeu de paume printed in 1632. It shows players in a walled indoor court with a sloping roof (the “penthouse”) along one side, which the ball could be played off. The printer accidentally flipped the picture, so the penthouse appears on the wrong side.

Look closely

- Find the two players. What are they holding? How long are their rackets compared with their arms?
- Look at the player in front. Are his knees bent? Where is his weight?
- Find the net and the spectators. How is this court different from a tennis court today?
- Look at the rackets drawn at the top corners. How are they different from modern rackets?

Talk about it

1. Why would a racket let these players hit the ball harder than the palm of the hand?
2. Why do you think Wingfield wanted a game that could be played outdoors on a lawn?

3. What would happen to a game if every court had different rules? How did the first Wimbledon fix that?

Safety first. Play balloon games in a clear room away from lamps, windows and furniture corners. Keep your paper-plate racket below the height of anyone's face when others are near, and swing only when you have a clear space around you.

PROJECT

Palm or Racket? A Balloon Rally Test

You will test the early history of tennis yourself: first with the palm of your hand, then with a short racket, then with a longer one. You will count how many hits you can keep in the air and measure how high you can send the balloon.

You will need

- Two or three round balloons
- Two paper plates, a ruler or paint stirrer and a wooden spoon or long cardboard tube for handles, and tape
- A tape measure and masking tape to mark heights on a wall
- A partner and the scorebook

Steps

1. Make two rackets: a short one (paper plate taped to a wooden spoon) and a long one (paper plate taped to a longer stick or cardboard tube).
2. **Predict.** With which will you keep the balloon up longest: palm, short racket or long racket?
3. Count how many hits in a row you make with your palm before the balloon touches the floor. Do it three times and write down the best.
4. Do the same with the short racket and then the long racket.
5. Height test: stand next to a wall with tape marks every 50 cm. Hit the balloon straight up three times with each and have a partner note the highest mark it reaches.
6. Rally with a partner over a “net” (a string tied between two chairs) using the short rackets. Count your longest rally.
7. Make a table and write which tool worked best for control and which for height. Was it the same one?

Tips

- Watch the balloon all the way onto the plate.
- Hit with a flat plate face for a straight-up bounce.

Check your work

- ☐ I tested palm, short racket and long racket three times each.
- ☐ I measured heights and recorded my longest rally.
- ☐ I can explain why the racket is a longer lever.

SCOREBOOK

1. Draw an arm and racket as a lever and mark which point moves fastest.
2. Make a time line: the jeu de paume (1100s), rackets (1500s), Wingfield's lawn tennis (1874), the first Wimbledon (1877).
3. Copy your project table and write one sentence comparing control and height.

From history. The jeu de paume is still played today under the name real tennis, on a few dozen indoor courts in England, France, Australia and the United States. Some of those courts are hundreds of years old.

COMMON MISTAKES

- Taking your eyes off the balloon just before hitting it.
- Swinging wildly with a long racket. A longer lever is faster, but harder to control at first.

Make it a game • Palm Rally Story. Play balloon rally with bare hands, counting hits aloud, then with a paper-plate racket. While you rally, take turns telling one fact in the story from the jeu de paume to Wimbledon 1877. A dropped fact ends the turn. Finish by saying how a racket makes the arm a longer lever.

3.2 THE READY POSITION AND THE SPLIT STEP

OBJECTIVES

- Show the tennis ready position and the split step.
- Explain reaction time and why a small hop before the opponent hits lets you move sooner.
- Measure reaction time with a ruler-drop test and a ball-drop test.

Warm-up. Have a partner hold a ruler just above your open fingers and drop it without warning. Catch it as fast as you can and read the centimeter mark where you caught it. Do it five times. The lower the number, the faster your reaction.

WATCH

Tennis Beginner Lesson: Why, When and How To Split-Step + Drills

Meike Babel Tennis • 4:25

<https://www.youtube.com/watch?v=UtARjzWH5PQ>

WHEN TO WATCH

After the physics paragraph. Watch exactly when the coach lands from her split step, and try the partner drills.

KEY TERMS

ready position

Feet about shoulder-width apart, knees bent, weight forward on the balls of the feet, racket in front: the stance you wait in.

split step

A small hop that lands on both feet, just as the opponent hits the ball, so you can push off quickly in any direction.

reaction time

The time between seeing something and starting to move.

recovery

Moving back to a good position after each shot to be ready for the next one.

CORE IDEAS

The story. Molla Bjurstedt Mallory came to the United States from Norway and won the U.S. women's singles championship eight times between 1915 and 1926, more than any other woman before or since. Players of her time stood on grass courts watching an opponent hit a ball that could reach them in about a second. Today the

best players serve faster than 200 kilometers an hour, and the ball can reach the other end of the court in about half a second. To get to such balls at all, every good player uses two habits: the **ready position** and the **split step**.

How they figured it out. Scientists who study movement measured how long people take to react. Even a fast person needs roughly a fifth of a second (0.2 seconds) after seeing the ball before the body starts to move. Coaches noticed that players who waited flat-footed were always a step late, while players who gave a tiny hop just as the opponent hit the ball pushed off sooner. They named that hop the split step, because the feet split apart as the player lands.

The physics. In the **ready position**, your knees are bent and your weight is on the balls of your feet. Your center of gravity is low and balanced over your base, so you can tip it in any direction quickly. The **split step** adds a spring. When you land from a small hop, your leg muscles and tendons stretch like rubber bands and then snap back, giving you a faster push than if you started from standing still. Timing is everything: if you land too early, the spring is gone; if you land too late, you are still in the air when you need to move.

On the field. Watch any tennis match and you will see players hop just as the opponent swings, every single point. Players in soccer, basketball, volleyball and baseball use the same move: a shortstop takes a small hop as the pitch reaches the batter, and a goalkeeper hops as the shooter kicks. After each shot, a good player also recovers back toward the middle so the next split step starts from a good spot.

PICTURE STUDY



Molla Mallory on the Court, Unknown photographer, About 1920 · Photograph · Library of Congress, Prints and Photographs Division

Image: [Wikimedia Commons](#), public domain

Molla Mallory was one of the best players in the world in the 1910s and 1920s. In this photograph she is moving across a grass court during a match, in the long white dress women wore for tennis in those years.

Look closely

- Look at her feet. Is she standing still or moving?
- Look at her knees and body. Is her center of gravity high or low?
- Where is her racket? Is it ready in front of her, or hanging down?
- Find the white lines on the grass. How might she use them to know where to recover?

Talk about it

1. How could a split step help her reach a ball hit to the far corner?
2. Her long dress made running harder than it is in today's tennis clothes. What else might have made tennis harder then?
3. Why is it important to be ready before your opponent hits the ball, not after?

Safety first. Do footwork drills on carpet or grass in proper shoes, never in socks on a smooth floor. Clear the space of toys and furniture. Hop small; the split step is a tiny bounce, not a big jump.

PROJECT

Reaction Lab

You will measure your reaction time, then test whether the split step helps you reach a dropped ball faster.

You will need

- A 30 cm ruler
- A tennis ball or other bouncy soft ball
- Masking tape
- A partner and the scorebook

Steps

1. **Ruler drop:** do ten catches with your writing hand and ten with your other hand. Record each and find the averages.
2. **Ready position:** practice the ready position in front of a mirror: feet apart, knees bent, weight forward, hands in front. Hold it for 10 seconds, three times.
3. **Split step:** practice the split step: a tiny hop that lands on both feet with knees bent. Do it ten times to a partner's clap.
4. Mark your starting spot. Your partner stands 2 meters away, holding a ball out at shoulder height to your left or right.
5. **Predict.** Will you catch more drops after a split step or from standing still?
6. **Flat-footed:** stand still. Your partner drops the ball without warning. Try to catch it after one bounce. Do ten tries and record catches.
7. **Split step:** this time, do a small split step just as your partner lets go. Do ten tries and record catches.
8. Compare. Then switch places and test your partner.

Tips

- The split step should land just as the ball is released, not before.
- Stay low as you push off; standing up wastes time.

Check your work

- ☐ I measured my reaction time with both hands.
- ☐ I compared ten flat-footed tries and ten split-step tries.
- ☐ I can show a correct ready position and split step.

SCOREBOOK

1. Draw a stick figure in the ready position and label the knees, weight and racket.
2. Record your ruler-drop results and averages.
3. Record your ball-drop catches in a table: flat-footed versus split step.

From history. Mallory was born Anna Margrethe Bjurstedt in Norway and won a bronze medal for Norway at the 1912 Olympic Games before moving to New York. Her eight U.S. singles titles are still a record for the championship, shared with no one.

WORKED EXAMPLES

Example 1. In the ruler-drop test, your catches were at 18, 15, 20, 16 and 16 cm. What is your average catch distance?

Show solution

1. Add the five numbers: $18 + 15 + 20 + 16 + 16 = 85$.
2. Divide by the number of tries: $85 \div 5 = 17$.

Answer: 17 cm. A ruler falls about 17 cm in a little under 0.19 seconds, so your reaction time is about two-tenths of a second.

COMMON MISTAKES

- Hopping too high, so you are still in the air when the ball comes.
- Standing up straight between points instead of staying low and ready.

Make it a game · Split Step Sprint. Stand in ready position while your parent holds a ball, then drops it. Do the split step hop just before the drop and race to catch it after one bounce. Do it once without the hop. Tell your parent which felt faster and why. Best of five rounds wins a point for each hop that worked.

3.3 THE FOREHAND

OBJECTIVES

- Show the forehand: turn, swing low to high, contact in front, follow through.
- Explain how the angle of the racket face decides where the ball goes.
- Practice the forehand with a balloon and then a soft ball, and record how many land in a target.

Warm-up. Hold a book flat and drop a small ball onto it so it bounces up. Now tilt the book a little and drop the ball again. Which way did the ball go? Try three different tilts and describe what you see.

WATCH

Tennis Coaching for Kids: Forehand

intosport · 2:14

<https://www.youtube.com/watch?v=VDD5iDmR0Jc>

WHEN TO WATCH

After the physics paragraph. Watch the young player turn, swing low to high and finish, and copy him with your paper-plate racket.

KEY TERMS

forehand

A stroke hit on the same side of the body as the hand holding the racket.

racket face

The flat, strung surface of the racket. Its angle at contact sets the direction of the ball.

contact point

Where the racket meets the ball: for a forehand, a little in front of the body and about waist high.

topspin

Forward spin on the ball, made by swinging from low to high. It helps the ball dip down into the court.

CORE IDEAS

The story. Hazel Hotchkiss grew up in California in the early 1900s. She was a frail child, and her doctor told her to take up a sport to grow stronger. Her brother suggested tennis, and she learned to play on the courts of the nearby University of California at Berkeley. She liked to attack: she came forward and hit the ball early,

before it could bounce high. She won the U.S. women's singles championship three years in a row, from 1909 to 1911, and again in 1919. As Hazel Hotchkiss Wightman she spent the rest of her long life playing, encouraging and teaching younger players, and in 1923 she gave a silver cup for a yearly match between British and American women, which became known as the Wightman Cup.

How they figured it out. Coaches like Mrs. Wightman watched thousands of strokes and saw the same pattern in the best ones. The player turns sideways early, takes the racket back, steps toward the ball, swings forward from low to high, hits the ball a little in front of the body, and finishes with the racket up over the opposite shoulder. Players who hit late, beside or behind the body, sprayed the ball off to the side. Players who swung only with the arm hit weakly. The forehand, like the throw, is a kinetic chain: legs, hips, trunk, shoulder, arm and racket.

The physics. When a ball bounces off the strings, it leaves in a direction set mostly by the angle of the **racket face** at the moment of contact, just like the ball bouncing off your tilted book. Face the strings toward the target and the ball goes there. Tilt the face up and the ball goes high; tilt it down and the ball goes into the net. Swinging from **low to high** brushes the back of the ball upward and makes it spin forward. That **topspin** makes the air push the ball down, so a player can swing hard and still have the ball dip into the court.

On the field. Coaches teach beginners to say “turn, swing, hit, finish.” They have them practice with slow balls, often bounced from a short distance, so the student has time to get the racket face square to the target. Today most players hit the forehand with a strong low-to-high swing for topspin. At home, a balloon gives you time to turn and swing, and a soft ball bounced against a wall lets you practice your contact point again and again.

PICTURE STUDY



Hazel Hotchkiss Wightman Playing Tennis, Unknown photographer, About 1910 · Photograph · Library of Congress, Prints and Photographs Division

Image: [Wikimedia Commons](#), public domain

Hazel Hotchkiss was the best American woman player when this photograph was taken. She was famous for coming forward to hit the ball early, and here she is reaching up for a high ball, stretching the lever of her arm and racket as far as it will go.

Look closely

- Find the racket. Where is its face pointing?
- Look at her free arm. How is she using it for balance?
- Look at her feet. Is she on her heels or her toes?
- Look at her eyes. What are they watching?

Talk about it

1. If she wanted to send this ball down into the court, how would she need to angle the racket face?
2. Why does reaching up with a long racket help her get to high balls?
3. Mrs. Wightman taught young players for decades. What makes a good teacher of a sport?

Safety first. Use balloons or soft foam balls indoors, never a hard tennis ball near windows or lamps. Keep a clear swing circle around you (two racket lengths) and make sure no one stands behind you when you take the racket back.

PROJECT

Forehand Target Practice

You will learn the forehand in steps with a balloon, then hit a soft ball to a target and keep a tally of good contacts.

You will need

- Balloons and a soft foam ball
- A paper-plate racket or a lightweight plastic or junior racket
- Masking tape for a target square (1 meter by 1 meter) on the floor or a wall
- A partner to toss, and the scorebook

Steps

1. **Shadow swings:** without a ball, practice “turn, swing, hit, finish” ten times, slowly, in front of a mirror if you can.
2. **Balloon forehands:** your partner tosses a balloon to your forehand side from 2 meters away. Turn, swing low to high and hit it back to your partner. Do 20.
3. Mark a target square 3 meters away. **Predict** how many soft-ball forehands out of 20 will land in it.
4. Your partner tosses the soft ball underhand so it bounces once in front of you. Hit it toward the target. Record 20 tries: in, long, short, left or right.
5. Look at your misses. If most went left or right, check your contact point; if most went long or short, check your racket face angle.
6. Make one change and hit 20 more. Record them the same way.
7. Compare your two sets of 20.

Tips

- Hit the ball a little in front of your front hip.
- Finish with the racket up by your opposite shoulder.

Check your work

- ☐ I hit 20 balloon forehands with a full swing.
- ☐ I recorded 40 soft-ball forehands and where each landed.

- ☐ I made one change based on my misses and compared the results.

SCOREBOOK

1. Draw the four forehand steps: turn, swing, hit, finish.
2. Draw a ball bouncing off a racket face at three angles and show where each ball goes.
3. Record your target tally for both sets of 20 and write what change you made.

From history. Hazel Hotchkiss Wightman won 45 U.S. national titles in singles, doubles and mixed doubles over her life, and two Olympic gold medals in doubles in 1924. People called her the “Queen Mother of American tennis.”

COMMON MISTAKES

- Hitting the ball late, beside or behind the body.
- Stopping the swing at contact instead of finishing over the shoulder.
- Swinging only with the arm instead of turning the body.

Make it a game • Racket Face Riddles. Your parent names a place to send a balloon, such as high and left, and you show the forehand turn and low-to-high swing slowly, saying which way the racket face must tilt. Swap and have your parent riddle you. Each correct angle with a clear explanation scores a point. Play to eight.

Scripture. “And if a man also strive for masteries, yet is he not crowned, except he strive lawfully.” (2 Timothy 2:5, KJV)

In tennis the ball must land inside the lines to count. Playing by the rules, and calling the lines honestly, is part of striving well.

3.4 THE SERVE IS A THROW

OBJECTIVES

- Show that a good tennis serve uses the same kinetic chain as an overhand throw.
- Practice a steady ball toss and contact high and in front.
- Measure overhand throws and balloon serves and compare them.

Warm-up. Throw a soft ball overhand at a wall target five times. Now hold a paper-plate racket and make the same motion very slowly without letting go of the racket. Where does your hand go at the top? Is it the same path as your throw?

WATCH

Tennis Coaching for Kids: Overarm Serve

[intosport](https://www.youtube.com/watch?v=AZECERNmVIs) · 2:37

<https://www.youtube.com/watch?v=AZECERNmVIs>

WHEN TO WATCH

After the story. A young player shows the overarm serve step by step; copy each step slowly.

BACKUP VIDEO

The Tennis Serve IS Definitely A Throwing Motion

[Performance-Plus Tennis](https://www.youtube.com/watch?v=n3EbtMM1jMw) · 6:35

<https://www.youtube.com/watch?v=n3EbtMM1jMw>

For older students: a coach shows why the serve is a throwing motion.

KEY TERMS

serve

The stroke that starts every point, hit overhand from behind the baseline into the box on the other side.

toss

Lifting the ball straight up with the non-racket hand to the place where you will hit it.

trophy position

The moment in the serve when the tossing arm points up, the racket is behind the head and the knees are bent, like a sports trophy.

pronation

The turning of the forearm just before and after contact, the same turn your arm makes at the end of a throw.

CORE IDEAS

The story. In the early days of lawn tennis many players served underhand or with a gentle sidearm push. Maurice McLoughlin, born in Nevada in 1890 and raised in California, changed that. Fans called him the “California Comet,” and he was known above all for his powerful serve and overhead. He won the U.S. championship in 1912 and 1913, and in 1913 he became the first American man to reach the singles final at Wimbledon. Crowds in England had rarely seen anyone serve so hard. After McLoughlin, everyone who wanted to win had to learn to serve overhand with power.

How they figured it out. Coaches noticed that the best servers looked like baseball pitchers. They turned sideways, bent their knees, reached back with the racket behind the head, and then exploded upward, swinging the racket the same way a pitcher swings his arm. Modern scientists filmed servers and pitchers at high speed and found the same order of body parts in both. That is why coaches tell beginners, “If you can throw, you can serve.” Some coaches even have players practice by throwing old rackets or balls over the net.

The physics. The serve is a kinetic chain (Lesson 1.3). The legs push up, the hips and trunk turn, the shoulder rotates, the elbow straightens, and the forearm turns over just before contact. Each link speeds up the next. Because the racket is a long lever, the racket head ends up moving far faster than the hand. Hitting the ball high, with the arm fully stretched, also helps: from a higher point there is a better angle down over the net into the service box. A steady toss is essential, because the whole chain is aimed at the place the ball will be.

On the field. Beginners learn the serve in pieces: toss, trophy position, swing, and then all together. Many start with an easy, short service motion and add the full chain once the toss is steady. The serve is the one shot in tennis that the player controls completely, so it rewards patient practice. At home you can practice the toss with any ball, the throwing motion with a soft ball, and the full serve with a balloon.

PICTURE STUDY



*Maurice McLoughlin at Wimbledon, Agence Rol (press photographer), July 4, 1913 · Photograph ·
Bibliothèque nationale de France*

Image: [Wikimedia Commons](#), public domain

A French press photographer caught Maurice McLoughlin at full stretch during his match at Wimbledon in 1913. The crowd behind him came to see the American with the thundering serve.

Look closely

- Look at how high his racket is. Why would hitting from up high help on a serve or an overhead?
- Find his back leg. What does it tell you about how hard he pushed off the ground?
- Look at his free arm. Where is it, and what might it be doing for his balance?
- Compare his shape with a pitcher or a person throwing a ball. What is the same?

Talk about it

1. Which links of the kinetic chain can you see in this photograph?
2. Why did McLoughlin's powerful serve force other players to change how they played?
3. What would happen to his shot if his toss went too far behind him?

Safety first. Warm up your shoulder with arm circles and easy throws first. Throw soft balls only, toward a wall or into a yard with no one in front of you. Serve balloons indoors in a room with a high ceiling and nothing breakable overhead. Stop if your shoulder hurts and tell a parent.

PROJECT

Throw, Then Serve

You will test whether better throwing makes a better serve. First you will measure your toss and your overhand throws; then you will learn the serve in pieces with a balloon and a soft ball.

You will need

- A soft ball or rolled-up socks
- Balloons and a paper-plate or junior racket
- A tape measure and masking tape
- A hula hoop or a tape circle on the floor (about 60 cm across)
- A partner and the scorebook

Steps

1. **Toss test:** stand in the hoop. Toss a ball straight up about as high as you can reach with a racket and let it land. Did it land inside the hoop, in front of your front foot? Do 20 tosses and count the good ones.
2. **Throw test:** make five overhand throws with a soft ball using the whole kinetic chain and measure each distance.
3. **Trophy position:** practice getting into the trophy position: side-on, knees bent, tossing arm up, racket behind your head. Hold it for a count of three, ten times.
4. **Balloon serve:** toss a balloon up, reach up and hit it with your racket toward a target on the wall at least 3 meters away. Do 20 and count how many hit the target area.
5. **Soft-ball serve (outdoors or a large room):** with a parent's permission, serve a soft foam ball over a string "net" toward a target box marked with tape. Do 20 and record in or out.
6. Do ten more good throws, then ten more serves. Did the throws warm up your serve?
7. Write two ways your throw and your serve are alike.

Tips

- Most bad serves start with a bad toss. If the toss is wrong, catch it and start over.
- Reach up: hit the ball at the top of your reach, with a straight arm.

Check your work

- ☐ I tested my toss 20 times and my throw 5 times.
- ☐ I can hold a correct trophy position.
- ☐ I recorded balloon and soft-ball serves and compared them with my throwing.

SCOREBOOK

1. Draw a thrower and a server side by side at the same moment. Circle the parts that look the same.
2. Record your toss, throw and serve tallies.
3. Write a short serving routine you could use every time (for example: bounce the ball twice, breathe, toss, swing).

From history. McLoughlin was the first men's champion of the United States to come from the western states, where tennis was usually played on fast, hard courts instead of grass. His fast, attacking style helped make tennis popular across America.

COMMON MISTAKES

- Tossing the ball too low or behind the head.
- Serving with only the arm, without bending the knees and turning the body.
- Rushing the serve. It is the one shot you control completely, so take your time.

Make it a game • Throw or Serve?. Mix the moves. Your parent calls either throw or serve, and you act out the matching steps in the right order, naming each link of the chain. Then call a mystery move that is neither, and your parent must spot it. Add the ball toss: ten tosses, and count how many land in the same spot.

UNIT 3

TENNIS

Tennis began as a game played with the palm of the hand in the courtyards of medieval France and grew into the lawn tennis of the first Wimbledon Championship in 1877. In this unit you will follow that story and then learn the body mechanics every tennis player uses: a ready position and split step that let you react in a fraction of a second, a forehand that swings the racket like a long lever, and a serve that is really an overhead throw.

You will practice with balloons and soft balls indoors, and with a paper-plate or soft racket, so you can learn good form without a court. If your family can visit a public court, a parent can come along and watch you try what you learned.

PREREQUISITES

- Knows the athletic stance and the center of gravity (Lesson 1.2)
- Knows the kinetic chain and the order of a good throw (Lesson 1.3)
- Can measure time with a stopwatch and find an average

MASTERY CHECKLIST

- ☐ I can tell how tennis grew from the jeu de paume to the first Wimbledon in 1877.
- ☐ I can show the ready position and the split step and explain why they make me faster.
- ☐ I can explain how the racket works as a lever and how the angle of the strings sends the ball.
- ☐ I can show that a good serve uses the same kinetic chain as an overhand throw.
- ☐ I can practice tennis skills safely at home with a balloon or a soft ball.

OPTIONAL BOOKS AND GAMES FOR THIS UNIT

- **USTA: Youth Tennis:** Free information from the United States Tennis Association about youth tennis with smaller courts, lower-bouncing balls and shorter rackets, and how to find a program. Fits the whole unit. A parent should preview it.

Not required. Every project in this unit works without them. School Launch has no ties to these authors, publishers or companies.

LESSONS IN THIS UNIT

3.1 From the Jeu de Paume to Wimbledon

2 sessions of 45 minutes

3.2 The Ready Position and the Split Step

2 sessions of 45 minutes

3.3 The Forehand

2 sessions of 45 minutes

3.4 The Serve Is a Throw

2 sessions of 45 minutes

UNIT 3 REVIEW

Answer each question in complete sentences. Show your work for the calculation. You may stand up and show a movement. The review is worth 50 points.

1. (5 pts)

What was the jeu de paume, and how did Major Wingfield change the game in 1874?

2. (5 pts)

What happened at Wimbledon in July 1877, and who won?

3. (5 pts)

Why does a ball hit with a racket go faster than a ball hit with the palm?

4. (5 pts)

Describe the ready position and tell why each part helps.

5. (5 pts)

What would happen if a player did the split step much too early?

6. (5 pts)

Your ruler-drop catches are 14, 18, 16 and 16 cm. What is the average?

7. (5 pts)

What mainly decides where the ball goes after it hits the racket?

8. 5 pts

Why do players swing from low to high on the forehand?

9. 5 pts

Name four links of the kinetic chain in a tennis serve, in order.

10. 5 pts

Why is the toss so important in the serve?

ANSWER KEY

1. The “game of the palm,” a medieval French indoor game first played with the hand and later with rackets. Wingfield patented an outdoor version that could be played on a lawn: lawn tennis.
2. The first Lawn Tennis Championship was held under fixed rules; twenty-two men entered and Spencer Gore won.
3. The racket makes the arm a longer lever, so its far end moves faster for the same turn of the arm, and the strings spring back like a trampoline.
4. Feet shoulder-width apart for a wide base; knees bent for a low center of gravity and springy legs; weight on the balls of the feet to move quickly; racket in front to be ready on either side.
5. The spring from landing would be used up before the opponent hit, so the player would be standing still again and would react late.
6. $14 + 18 + 16 + 16 = 64$; $64 \div 4 = 16$ cm.
7. The angle of the racket face at the moment of contact.
8. It puts topspin on the ball, which makes it dip down into the court, so the player can swing hard and still keep the ball in.
9. Any four in order: legs push up, hips turn, trunk turns, shoulder rotates, elbow straightens, forearm turns over, racket.
10. The whole swing is aimed at the place the ball will be. A toss that is too low, too far back or to the side forces the player to change the swing, and the serve goes wrong.

PORTFOLIO PIECE: A TENNIS COACHING CARD FOR A YOUNGER CHILD

Make a folded coaching card (or a short slideshow) that teaches a younger brother, sister or friend to play balloon tennis. Include four panels: the ready position and split step, the forehand, the toss and serve, and safe balloon-tennis rules. Use your own drawings or photographs of yourself. Then teach the child for 15 minutes and write a short report: what you taught, what was hard for the child, and what you changed in your teaching.

LOOK FOR	WHAT IT MEANS
Correct technique	Each panel shows the skill correctly with the key words (knees bent, contact in front, low to high, toss in front).
Clear pictures	Drawings or photos are labeled and easy for a younger child to follow.
Safety	The card includes sensible safety rules for playing indoors.
Teaching report	The report describes a real lesson honestly and names one change that helped.

UNIT 4

GOLF

Golf grew up on the windy seaside links of Scotland, where the town of St Andrews has been called the home of golf. In this unit you will meet Old Tom Morris, who played, built clubs and balls and cared for the Old Course for nearly forty years, and Harry Vardon, whose famous grip is still used by most golfers today. You will learn why the golf ball changed from stuffed leather to rubber to the dimpled ball we know.

Then you will learn the body mechanics of golf: a good grip and stance, a putting stroke that swings like a pendulum, and a full swing that uses the kinetic chain. You will build a putting course in your house and practice the full swing outdoors with a broomstick or a plastic club, safely, with an adult watching.

PREREQUISITES

- Knows the pendulum and what changes its swing (Lesson 2.3)
- Knows the kinetic chain (Lesson 1.3) and the athletic stance (Lesson 1.2)
- Can measure in centimeters and find an average

MASTERY CHECKLIST

- ☐ I can tell the story of Old Tom Morris and how the golf ball changed.
- ☐ I can hold a club with the Vardon (overlapping) grip and take a balanced stance.
- ☐ I can make a pendulum putting stroke and control distance with the length of the backstroke.
- ☐ I can explain the full swing as a kinetic chain and swing safely outdoors.
- ☐ I can design and play a household putting course and keep score.

OPTIONAL BOOKS AND GAMES FOR THIS UNIT

- **Harry Vardon, The Complete Golfer (1905):** Free on Project Gutenberg. Vardon's own book on the grip, stance and swing, with his photographs. Older language; best for ages 11 and up or read aloud by a parent. Fits Lessons 4.2 and 4.4.
- **U.S. Kids Golf:** Information on junior clubs sized to a child's height and on junior golf programs. Not needed for this unit, which uses a broomstick or plastic club. A parent should preview it.

Not required. Every project in this unit works without them. School Launch has no ties to these authors, publishers or companies.

LESSONS IN THIS UNIT

4.1	Old Tom Morris and St Andrews	2 sessions of 45 minutes
4.2	Grip and Stance: Vardon's Grip	2 sessions of 45 minutes
4.3	The Pendulum Putt	2 sessions of 45 minutes
4.4	The Full Swing with a Broomstick	2 sessions of 45 minutes

UNIT 4 REVIEW

Answer each question in complete sentences. Show your work for the calculation.
The review is worth 50 points.

1. **5 pts**
Who was Old Tom Morris? Give three facts about him.
2. **5 pts**
Why did the gutta-percha ball replace the feathery?
3. **5 pts**
What do dimples do for a golf ball?
4. **5 pts**
Describe the Vardon (overlapping) grip and tell why it helps.

5. (5 pts)

Describe a good golf stance.

6. (5 pts)

In putting, how do you make the ball roll farther without changing your rhythm?

7. (5 pts)

What does a Stimpmeter measure, and why is it a fair test?

8. (5 pts)

A 20 cm backstroke rolls a ball 2 m. A 40 cm backstroke rolls it 5 m. Estimate the backstroke for a 3.5 m putt.

9. (5 pts)

What would happen if a golfer released the wrists too early in the downswing?

10. (5 pts)

Give three safety rules for swinging a club or broomstick.

ANSWER KEY

1. Any three: born in St Andrews in 1821; apprentice to Allan Robertson; won the Open four times (1861, 1862, 1864, 1867); oldest Open champion at 46; Keeper of the Green at St Andrews from 1864 to 1903; father of Young Tom.
2. Gutties were cheaper, tougher, quicker to make and did not fall apart when wet, so more people could play.
3. They help air flow hug the ball so the wake is smaller and there is less drag, and with backspin they help lift the ball, so it flies higher and farther.
4. The little finger of the lower hand rests on top of the gap between the first two fingers of the top hand. It joins the hands so they work as one unit and do not twist the clubface.
5. Feet about shoulder-width apart, knees flexed, bending from the hips with a straight back, weight balanced over the feet.
6. Make a longer backstroke; the putter swings like a pendulum, and a higher backswing makes it move faster at the bottom.
7. Green speed. The same ramp, the same height and the same ball are used every time, so only the green changes.
8. About 30 cm, halfway between, then test and adjust.
9. The club would reach its top speed before the ball, so the clubhead would be slowing down at impact and the shot would be weaker (and often hit fat or thin).
10. Any three: swing only outdoors; keep a clear circle; an adult watches; look around before every swing; never swing toward people, windows or cars; use plastic or foam balls.

PORTFOLIO PIECE: THE FAMILY PUTTING OPEN

Host a putting tournament on your household course (rebuilt or improved from Lesson 4.3) with at least three family members. Prepare a printed course map with each hole's length and par, a scorecard for each player, and a one-page "Rules of the Course" sheet, including safety rules and one rule about honest scoring. Before play, give a two-minute lesson on the pendulum putt. Afterward, post the results and write a short reflection: Which holes were hardest, and how would you redesign one of them?

LOOK FOR	WHAT IT MEANS
Course design	Nine holes with measured lengths, sensible pars and at least one bank shot and one break.
Teaching	The two-minute lesson correctly explains the pendulum stroke and distance control.
Records	Scorecards are complete and totals and comparisons with par are correct.
Reflection	The reflection names a hard hole and gives a specific redesign with a reason.

4.1 OLD TOM MORRIS AND ST ANDREWS

OBJECTIVES

- Tell the story of Old Tom Morris and the Old Course at St Andrews.
- Explain how the golf ball changed from the feathery to the gutta-percha to the dimpled ball, and why.
- Test how different household balls roll and bounce, and record the results.

Warm-up. Collect three different small balls: a ping-pong ball, a golf ball or rubber ball, and a ball of rolled-up paper or socks. Drop each from the height of a table onto a hard floor. Which bounces highest? Then roll each across the floor with the same gentle push. Which rolls farthest?

WATCH

Old Tom Morris: Golf's Greatest Pioneer

St Andrews Links • 3:05

<https://www.youtube.com/watch?v=sgsEVxYTsqI>

WHEN TO WATCH

After the story. Made with St Andrews Links, it visits the records, streets and grave of Old Tom Morris.

BACKUP VIDEO

Old Tom Morris: 200 Years On

St Andrews Links • 3:02

https://www.youtube.com/watch?v=4hp_bCLWjSE

A second short film from St Andrews Links about Old Tom's life and work.

KEY TERMS

links

A seaside golf course built on sandy ground between the beach and the farmland, as in Scotland.

feathery

An early golf ball made of a leather cover stuffed tightly with wet goose feathers.

gutta-percha

A hard, rubbery sap from a Malaysian tree, used for golf balls from the late 1840s.

dimples

The small round dents on a golf ball that help it fly higher and farther.

CORE IDEAS

The story. Tom Morris was born in St Andrews, Scotland, in 1821, the son of a weaver. As a boy he became an apprentice to Allan Robertson, the best golfer in town, who made golf balls by hand. In 1848 Robertson fired him for playing with a new kind of ball. Tom moved to Prestwick, on Scotland's west coast, and helped start the first Open Championship there in 1860. He won it four times: in 1861, 1862, 1864 and 1867. In 1867 he was 46 years old, and he is still the oldest man ever to win the Open. In 1864 the golfers of St Andrews brought him home to be Keeper of the Green on the Old Course, and he cared for it until 1903. People called him "Old Tom" to tell him apart from his son, "Young Tom," who was also an Open champion.

How they figured it out. The ball that got Tom fired was the **gutta-percha** ball, or "guttie." Before it, golfers used the **feathery**: a leather pouch stuffed with a top hat full of wet feathers, which shrank as it dried into a hard ball. Featheries were expensive, slow to make and fell apart when wet. Gutties were made from hard tree sap that could be softened in hot water and shaped. They were cheap and tough, so many more people could play. Golfers then noticed something strange: a new, smooth guttie flew poorly, but an old, scuffed and nicked one flew farther. Ball makers began hammering patterns into new balls on purpose, which led, many years later, to the dimpled ball of today.

The physics. A ball flying through the air has to push the air out of the way. Behind a smooth ball the air breaks away early and leaves a big, swirling wake that drags the ball back. Little dents or bumps make a thin layer of air hug the ball longer, so the wake is smaller and there is less drag. Spin matters too. A golf ball hit well spins backward, and with the dimples that spin makes the air push the ball upward, so it stays in the air longer. The bounce and roll of a ball depend on how springy it is: a hard, springy ball bounces higher and rolls farther than a soft one.

On the field. Golfers choose their shots with these facts in mind. On a windy links course, they often hit the ball low so the wind affects it less, and they let it bounce and roll along the firm ground, as Old Tom's golfers did. On softer courses they hit

high shots that land and stop. Today's rules set limits on how far a ball may fly, so that the old courses like St Andrews are still a fair test.

PICTURE STUDY



The Golfers, Charles Lees, 1847 · Oil on canvas · Scottish National Portrait Gallery, Edinburgh

Image: [Wikimedia Commons](#), public domain

The Scottish painter Charles Lees painted this famous match on the links of St Andrews in the 1840s, when Tom Morris was a young man working for Allan Robertson. He made careful studies of real golfers, caddies and spectators of the town, and Allan Robertson sat for him too. The game was played with featheries and wooden-shafted clubs.

Look closely

- Find the golfer bending over his putt. How are his feet set, and where is he looking?
- Find the caddies carrying bundles of clubs under their arms. How many clubs can you see?
- Look at the ground. Is it a smooth green, or rough links turf?
- Look at the crowd. How can you tell this was an important match?

Talk about it

1. If you were the golfer putting, how would the crowd make you feel? How could you stay calm?
2. The players were using featheries. How would a feathery behave differently from a modern ball on this ground?

3. Why might golf have been easier to start on a seaside links than in a forest or on farmland?

Safety first. Drop and roll balls only in a clear space, away from glass, lamps and people. Pick up balls when you are finished so no one trips on them.

PROJECT

The Ball Test

Like the ball makers of St Andrews, you will test different balls to see how they bounce and roll, and decide which would make the best golf ball.

You will need

- Four or five small balls (a golf ball or rubber ball, a ping-pong ball, a tennis ball, a ball of rolled-up socks or paper, a marble)
- A tape measure or meter stick taped to a wall
- A short ramp: a book propped under one end of a board or a stiff folder
- A phone camera (optional) and the scorebook

Steps

1. **Predict.** Rank your balls from highest bounce to lowest and from longest roll to shortest.
2. **Bounce test:** hold each ball next to the meter stick at 100 cm and drop it (do not throw) onto a hard floor. A partner reads how high it bounces (or film it and pause). Do three drops for each ball and record the middle one.
3. **Roll test:** set up the ramp on a hard floor. Let each ball roll down from the same starting line without pushing. Measure how far it rolls from the bottom of the ramp. Do three rolls each.
4. Repeat the roll test on a carpet or rug. Which balls slow down most?
5. Make a table with each ball's bounce height and roll distances.
6. Choose the ball you think would make the best golf ball for a windy links course, and explain why.

Tips

- Drop each ball from exactly the same height, with your fingers simply opening.
- Use the middle of three tries to reduce the effect of one odd result.

Check your work

- ☐ I tested at least four balls, three times each, for bounce and roll.

- ☐ I recorded my results in a table.
- ☐ I chose a best ball and explained my choice with my data.

SCOREBOOK

1. Draw the three kinds of golf ball (feathery, guttie, dimpled) and write one fact about each.
2. Record your ball-test table and make a bar graph of bounce heights.
3. Draw a smooth ball and a dimpled ball flying through the air, with the wake of air behind each.

From history. Golf at St Andrews goes back to at least the 1500s. The Old Course has eighteen holes because in 1764 the golfers combined some short holes, reducing the course from 22 holes to 18. Other courses followed St Andrews, and eighteen became the standard round.

COMMON MISTAKES

- Throwing the ball down instead of dropping it, which makes the test unfair.
- Thinking dimples are only for decoration. They change how the air flows around the ball.

Make it a game • Ball Timeline Cards. Make three cards: feathery, gutta-percha and dimpled. On the back of each, write from memory what the ball was made of and why it changed. Shuffle and flip them. Your parent draws a card, and you teach about it in thirty seconds. Then tell one fact about Old Tom Morris and St Andrews.

4.2 GRIP AND STANCE: VARDON'S GRIP

OBJECTIVES

- Hold a club with the overlapping (Vardon) grip and check it with a simple test.
- Take a balanced golf stance: feet shoulder-width apart, knees flexed, bending from the hips.
- Explain why the hands must work together as one unit.

Warm-up. Hold a broom handle with your hands far apart and try to make a smooth swing back and forth (indoors, slowly, with nothing nearby). Then hold it with your hands touching, one just below the other, and swing again. Which felt smoother? Which way did your hands fight each other?

WATCH

The BEST Golf Grip Lesson on YouTube | The Legend Tom Watson

Golf Secrets • 6:16

<https://www.youtube.com/watch?v=LTHQtOX1fac>

WHEN TO WATCH

After the physics paragraph. The champion golfer Tom Watson shows the grip step by step; pause and copy each step with a stick or club.

BACKUP VIDEO

The Vardon Grip in Golf

World of Golf London • 1:44

<https://www.youtube.com/watch?v=8zXRb-lzWal>

A short second explanation of the Vardon grip.

KEY TERMS

overlapping grip

Also called the Vardon grip: the little finger of the lower hand rests on top of the gap between the first two fingers of the top hand, so the hands work as one.

interlocking grip

A grip in which the little finger of the lower hand hooks between the first two fingers of the top hand; good for small hands.

stance

How you stand to the ball: the width of your feet, the bend in your knees and hips, and where the ball sits.

posture

The angle of your back and the bend at your hips and knees as you stand over the ball.

CORE IDEAS

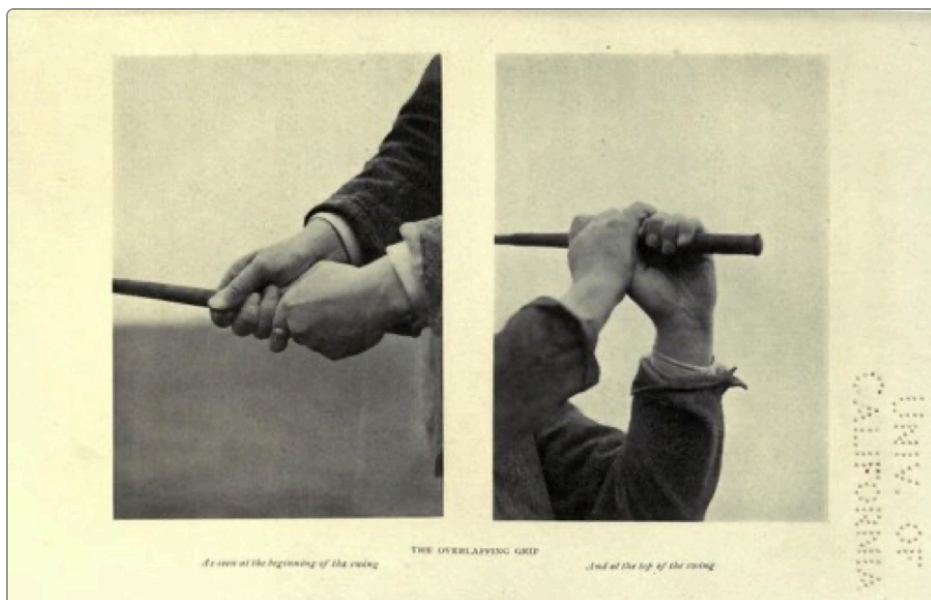
The story. Harry Vardon was born in 1870 on the island of Jersey, between England and France. As a boy he worked as a caddie and played with homemade clubs. He grew into the greatest golfer of his time, winning the Open Championship six times, a record that still stands, and the U.S. Open in 1900. Crowds came to watch him because he hit the ball so straight and so smoothly. Vardon held the club in a special way, with the little finger of his right hand resting on top of his left hand. He did not invent that grip, but he made it famous, and today it is called the **Vardon grip**. Most good golfers still use it or something close to it.

How they figured it out. Earlier golfers often held the club with all ten fingers on the grip and the hands apart, like holding a bat. Vardon and other players found that when the hands are apart, each one tries to do its own job, and the clubface twists. By overlapping the fingers, the two hands are joined into one unit that swings together. Vardon explained his grip and swing with photographs in his books *The Complete Golfer* (1905) and *How to Play Golf* (1912), so golfers everywhere could copy it.

The physics. In a swing, your arms and the club form a lever that turns around your body. If the two hands push or pull against each other, they add a **twist** to the club, and the clubface turns open or closed. A clubface turned just a little at impact sends the ball off line, just as a tilted racket face did in tennis. Joining the hands lets the whole club move as one piece. A good **stance** matters too: feet about shoulder-width apart give a stable base; flexed knees and a bend from the hips keep your center of gravity balanced over your feet, so you can turn without swaying.

On the field. Teachers check a beginner's grip first, before anything else, because nearly every swing problem can start there. They look for a grip that is firm but not tight (some say "like holding a small bird"), with the V-shapes made by thumb and finger pointing toward the right shoulder for a right-handed golfer. Younger players with small hands often use the interlocking grip instead, which also joins the hands. Then the teacher checks the stance: balanced, relaxed, ready to turn.

PICTURE STUDY



The Overlapping Grip, Harry Vardon (photographs in his book), 1912 · Photographs printed in *How to Play Golf* · Published in London

Image: [Wikimedia Commons](#), public domain

Vardon used photographs of his own hands to teach the grip in his book *How to Play Golf*. The caption says the left photograph shows the grip “as seen at the beginning of the swing” and the right one “at the top of the swing.”

Look closely

- Find the little finger of the lower hand. Where does it rest?
- Look at the thumbs. Do they point straight down the shaft or to the side?
- Compare the two photographs. Did the grip change at the top of the swing, or did the hands stay together?

Talk about it

1. Why would a grip that joins the hands make the clubface easier to control?
2. Why do you think Vardon used photographs instead of only words to teach his grip?
3. What is one other skill (writing, cutting with scissors, holding a bat) where how you hold the tool changes the result?

Safety first. Practice the grip and stance with a short stick or plastic club, without swinging, indoors. Any swinging, even small, happens outdoors with a clear circle and an adult watching.

PROJECT

Grip Check and Stance Test

You will learn the overlapping and interlocking grips, test which keeps the clubface steadier, and check your stance for balance.

You will need

- A broomstick, dowel or plastic golf club
- A piece of tape stuck flat on the end of the stick or the clubface to show which way the face points
- A mirror or a partner, and a phone camera (optional)
- The scorebook

Steps

1. Learn the grip in steps from the video and the picture: top hand first, then the lower hand with the little finger overlapping. Practice taking it off and putting it on ten times.
2. Learn the interlocking grip too. Choose which feels better for your hands.
3. **Predict.** Will a ten-finger grip with hands apart, or a joined grip, keep the tape flag steadier?
4. **Steadiness test (outdoors):** with an adult watching and a clear circle, make five slow half swings (hands to hip height and back) with hands apart. Have a partner watch the tape flag at the bottom of each swing: is it square, open or closed?
5. Do five slow half swings with your joined grip. Record the flag each time.
6. **Stance test:** stand in your golf stance, holding the stick. Have a partner give a gentle push on your shoulder from the front, back and side. Rate your balance from 1 (wobbly) to 3 (steady).
7. Try stances with feet together, shoulder-width and very wide. Which is steadiest while still letting you turn?
8. Write your grip and stance checklist in the scorebook.

Tips

- Hold firmly but not tightly; your forearms should feel relaxed.

- Bend from the hips, not by rounding your back.

Check your work

- ☐ I can take an overlapping or interlocking grip correctly.
- ☐ I compared a joined grip with hands apart and recorded the clubface each time.
- ☐ I found my steadiest stance and wrote a checklist.

SCOREBOOK

1. Trace your own hands in your grip, or draw them, and label the overlapping little finger and the V's.
2. Record your steadiness test: grip, swing number, square/open/closed.
3. Draw a side view of a golfer's stance and mark the knees, hips and the center of gravity.

From history. Vardon's six Open Championships came between 1896 and 1914. On his tours of America in 1900 and later, thousands of people came out to see him play, and he did a great deal to make golf popular in the United States.

COMMON MISTAKES

- Gripping so tightly that the arms tense up.
- Standing with straight, locked knees or a rounded back.
- Letting the hands slide apart during the swing.

Make it a game • Grip Inspector. Make a pretend club from a rolled towel. Your parent takes the role of the inspector and calls grip or stance. You build it, then explain each check aloud: overlapping little finger, feet shoulder-width, flexed knees, bend from the hips. The inspector may secretly change one thing, and you must find it.

4.3 THE PENDULUM PUTT

OBJECTIVES

- Make a putting stroke that rocks the shoulders like a pendulum, with quiet hands and wrists.
- Show that a longer backstroke sends the ball farther, and use it to control distance.
- Design, build and play a nine-hole household putting course.

Warm-up. Hold a book flat between your palms with your arms hanging straight down. Rock your shoulders so the book swings back and forth like a pendulum, without bending your wrists. Now try it while bending your wrists. Which motion is smoother and easier to repeat?

WATCH

Teaching Kids How to Putt - Coach Eric Eggleston

SportVideos · 1:54

<https://www.youtube.com/watch?v=EllmNZASKoE>

WHEN TO WATCH

After the physics paragraph. Watch how the coach keeps the young golfer's wrists quiet and rocks the shoulders.

BACKUP VIDEO

U.S. Kids Golf Tips With Jim Hardy E:1 Putting

Home of American Golf · 1:01

<https://www.youtube.com/watch?v=wIn-KC4xCOs>

A one-minute putting tip from U.S. Kids Golf.

KEY TERMS

putt

A gentle stroke on the green that rolls the ball along the ground toward the hole.

backstroke

How far the putter swings back before it comes forward.

green speed

How fast a green lets the ball roll; measured with a simple ramp called a Stimpmeter.

break

The curve of a putt caused by a slope in the green.

CORE IDEAS

The story. In 1935, an amateur golfer named Edward Stimpson watched a championship where the greens were so fast that some putts would not stop. He wanted a way to measure green speed, so that every course could be tested the same way. He invented a simple wooden ramp: a ball is let go from a notch and rolls down onto the green, and the distance it rolls is the green's speed. In the 1970s the United States Golf Association improved his design and shared it with golf courses as the **Stimpmeter**, and greenkeepers around the world still use it.

How they figured it out. Stimpson's idea was a **fair test**: same ramp, same height, same ball, so the only thing that changes is the green. Putting teachers used the same kind of thinking about the stroke. They found that golfers who hit at the ball with their hands and wrists rolled it different distances every time, while golfers who rocked their shoulders, with the arms and putter swinging together like a pendulum, made the same stroke again and again. They also found that the most reliable way to control distance is to change the length of the backstroke, keeping the same smooth rhythm.

The physics. A putter swinging from the shoulders is a **pendulum** (Lesson 2.3). The higher it swings back, the faster it is moving at the bottom, where it meets the ball, so a longer backstroke gives a faster, longer putt. Because a pendulum's swing takes about the same time whether it is long or short, a good putting stroke has the same rhythm for every length of putt. Once rolling, the ball slows down because of friction with the grass. On a slope, gravity also pulls the ball downhill, so it curves: that is the **break**. A slow-rolling ball near the hole breaks the most.

On the field. Good putters read the green by looking at the slope from behind the ball and from the side, pick a line, and then focus on the right speed. Many teachers say speed matters most, because a putt rolled at the right speed that misses usually stops close to the hole for an easy next putt. Putting needs little strength, so a careful young player can putt as well as an adult. It rewards patience and a calm, repeatable routine.

PICTURE STUDY



Golfer Putting on the Green Before a Large Gallery, Unknown photographer, Early 1900s · Photograph · Library of Congress, Prints and Photographs Division
Image: [Wikimedia Commons](#), public domain

This photograph from the early 1900s shows a golfer putting during a tournament. A long gallery of spectators stands behind a rope, silent while he putts. The most important strokes in golf are often the shortest.

Look closely

- Find the golfer who is putting. Is he bending from the hips? Are his eyes over the ball?
- Find the hole and the flag. Is the putt long or short?
- Look at the crowd. Are they moving or still? Why?

Talk about it

1. How might it feel to putt with hundreds of people watching? What could help you stay calm?
2. If this green sloped from left to right, where should the golfer aim?
3. Why does a smooth pendulum stroke work better under pressure than a quick jab with the hands?

Safety first. Putting is gentle: roll the ball, never swing hard indoors. Keep everyone out of the line of the putt and away from the putter. Pick up balls and obstacles when you finish so no one trips.

PROJECT

A Nine-Hole Household Putting Course

You will test your pendulum stroke, then build and play a nine-hole putting course on the carpet or floor with cups, books and other household objects.

You will need

- A putter, a plastic club, or a yardstick with a block taped to the end
- A golf ball, ping-pong ball or other small ball
- Nine cups or mugs laid on their sides, or tape circles, as holes
- Books, shoeboxes, pillows and a folded towel for hills, walls and obstacles
- Masking tape, a tape measure, paper for a scorecard and the scorebook

Steps

1. **Distance ladder:** put tape marks on the floor at 1, 2 and 3 meters. Using a short, medium and long backstroke (measure each against your shoe), putt five balls with each and measure where they stop. Make a table.
2. **Predict.** Which backstroke will you need for a 2.5 meter putt? Test it.
3. **Design:** on graph paper, plan nine holes of different lengths, with at least one bank shot, one “hill” made from a folded towel under the carpet, and one narrow gap between books.
4. Give each hole a par (the number of strokes a good player needs, usually 2 or 3).
5. Build the course. Measure each hole’s length and write it on the plan.
6. Make a scorecard and play the course twice. Keep score honestly.
7. Invite a family member to play and keep their score too. After the round, find each player’s total and compare it with par.
8. Write which hole was hardest and what you learned about speed and break.

Tips

- Keep your head still until the ball has rolled away.
- Use the same rhythm for every putt; change only the length of the backstroke.

Check your work

- ☐ I measured how backstroke length changes putt distance.
- ☐ I designed and built a nine-hole course with par for each hole.
- ☐ I played two rounds and recorded honest scores.

SCOREBOOK

1. Draw your course plan with each hole's length and par.
2. Record your distance ladder table and draw a line graph of backstroke length against distance.
3. Write a short putting routine you will use on every putt.

From history. Stimpson's original ramp was made of wood. Today a typical public course green might measure about 8 feet (2.4 meters) on the Stimpmeter, while greens at the biggest professional tournaments may roll 12 feet (3.7 meters) or more.

WORKED EXAMPLES

Example 1. On your course, a backstroke as long as your shoe (about 20 cm) rolls the ball 2 meters. A backstroke twice as long rolls it 5 meters. A putt is 3.5 meters long. About how long a backstroke should you try?

Show solution

1. 3.5 meters is about halfway between 2 m and 5 m.
2. Halfway between 20 cm and 40 cm is 30 cm.
3. Try a 30 cm backstroke, then adjust after watching the roll.

Answer: About 30 cm. Real putts do not follow exactly straight-line rules, so test it and adjust.

COMMON MISTAKES

- Using the wrists to hit at the ball instead of rocking the shoulders.
- Slowing down the putter just before the ball. Keep a smooth rhythm through the ball.
- Thinking only about the line and forgetting speed.

Make it a game • Backstroke Ladder. Use a short stick or a spoon to putt a ball over a rug. Mark where a short, medium and long backstroke send it, then guess before each putt where it will stop. Closest guess wins a point. Say aloud why the shoulders rock like a pendulum with quiet hands. Beat your own total after three rounds.

4.4 THE FULL SWING WITH A BROOMSTICK

OBJECTIVES

- Describe the full swing as a kinetic chain and a double pendulum.
- Make a balanced, safe full swing outdoors with a broomstick or plastic club.
- Test how swing length and a balanced finish change how far a plastic ball flies.

Warm-up. Outdoors, with a clear circle around you and an adult watching, hold a broomstick across your shoulders behind your neck. Turn your shoulders back until the end of the stick points at the ground in front of you, then turn through until it points the other way. Can you turn without your head moving side to side?

WATCH

5 JUNIOR GOLF TIPS W/ LEO BONIFACE & ME & MY GOLF! | American Golf

American Golf • 8:49

<https://www.youtube.com/watch?v=oMs26dH-XpQ>

WHEN TO WATCH

After the story. Two coaches give junior golfers tips on grip, posture and movement; watch for the balanced finish.

KEY TERMS

backswing

Turning the shoulders and swinging the club up and back before the downswing.

downswing

The part of the swing from the top down to the ball, starting with the lower body.

double pendulum

Two pendulums linked together, like the arms swinging from the shoulders and the club hinging at the wrists.

finish

The balanced position at the end of the swing, with the weight on the front foot and the chest facing the target.

CORE IDEAS

The story. In September 1913, the U.S. Open was played at The Country Club in Brookline, Massachusetts. The favorites were two great English professionals, Harry Vardon and Ted Ray. But a 20-year-old local amateur named Francis Ouimet, who

had grown up across the street from the course and worked there as a caddie, tied them after four rounds. The next day, in the rain, he beat them both in a playoff. His own caddie was a ten-year-old boy named Eddie Lowery. Ouimet's win made headlines across America, and many young people took up golf because of him.

How they figured it out. Ouimet had learned partly by watching good players and practicing on his own, sometimes on a homemade course near his house. Golf teachers since then have studied the swing more and more closely, first with photographs like Vardon's and later with high-speed film. They found that the best swings follow the same order as a good throw: a turn back, then the lower body starts the downswing, followed by the hips, chest, arms and finally the club. They also found that the swing works like a **double pendulum**: the arms swing from the shoulders, and the club swings from the wrists, which let it release late and fast.

The physics. The club is a long lever, and the clubhead is the fastest part of the whole chain. In a **double pendulum**, the second part (the club) can end up moving much faster than the first (the arms) if it is released at the right time. If the wrists let the club go too early, the speed is wasted before the ball. Balance matters too. Your center of gravity shifts toward your back foot on the backswing and to your front foot on the downswing. A swing that ends in a steady, balanced **finish** almost always had good timing; a swing that ends with a stumble did not.

On the field. Teachers start young golfers with short swings and balanced finishes before adding power. A common practice drill is to swing and then hold the finish for a count of three. Golf clubs are swung hard and fast, so safety rules on the course are strict: look around before every swing, never swing toward anyone, and stand well away from someone who is swinging. At home, a broomstick or plastic club and plastic practice balls let you learn the motion, but only outdoors and only with an adult watching.

PICTURE STUDY



Francis Ouimet in Full Swing, Agence Rol (press photographer), About 1913 · Photograph · Bibliothèque nationale de France

Image: [Wikimedia Commons](#), public domain

A French news agency photographed Francis Ouimet at the end of a drive, at about the time of his famous 1913 victory. He is in his finish, and his body tells us a great deal about the swing that came before.

Look closely

- Look at his feet. Which foot holds most of his weight? Is his back heel up?
- Look at his chest and belt buckle. Which way are they facing?
- Look at the club. Where is it pointing at the finish?
- Is he balanced, or about to fall over?

Talk about it

1. What does a balanced finish tell you about the timing of the swing?
2. Which links of the kinetic chain can you see have finished their turn?
3. Ouimet was a caddie who became a champion. What habits do you think helped him?

Safety first. Swing only outdoors, with a clear circle at least twice as long as your club in every direction, and an adult watching. Before every swing, look all around. Never swing toward a person, a window or a car. Use plastic practice balls or soft foam balls only. Wear shoes, and stop if your back or wrists hurt.

PROJECT

Balanced Swings, Measured

You will learn the full swing in three sizes (quarter, half and full) outdoors, hold your finish after each swing, and measure how far plastic practice balls fly.

You will need

- A broomstick with a sock taped over the end, a plastic golf club or a junior club
- Plastic practice (whiffle) golf balls or foam balls
- A tape measure and markers (cones, shoes or water bottles)
- An adult, a clear yard or park, and the scorebook

Steps

1. Set up your safety circle. Agree on a rule: no one walks in front of the hitter, and the hitter does not swing until the adult says, "Clear."
2. **Shadow swings:** without a ball, make ten quarter swings (hands to knee height), ten half swings (hands to hip height) and ten full swings, holding each finish for a count of three.
3. **Predict.** How far will a plastic ball fly with each size of swing?
4. Hit five balls with quarter swings. Measure where each first lands. Rate each finish: 1 (wobbly), 2 (okay), 3 (balanced).
5. Hit five balls with half swings and five with full swings, measuring and rating the same way.
6. Find the average distance for each swing size. Then compare your balanced (3) swings with your wobbly (1) ones. Which went farther and straighter?
7. If you have a phone, film one full swing from the side and look for the order: hips, chest, arms, club.
8. Write your best tip for a balanced swing.

Tips

- Swing at about 80 percent of your hardest. Balance and timing make more speed than swinging out of your shoes.

- Keep your eyes on the back of the ball until after you hit it.

Check your work

- ☐ I followed the safety circle rule every time.
- ☐ I measured and rated 15 swings of three sizes.
- ☐ I compared balanced and wobbly swings using my data.

SCOREBOOK

1. Draw a golfer at four moments: address, top of the backswing, impact and finish. Mark where the weight is in each.
2. Record your distance and balance table and find the averages.
3. Draw a double pendulum (shoulders, arms, wrists, club) and mark the two hinges.

From history. Ouimet remained an amateur all his life and later became the first American to be elected captain of the Royal and Ancient Golf Club of St Andrews, in 1951. His caddie Eddie Lowery grew up to be a successful businessman and a lifelong friend of the game.

COMMON MISTAKES

- Swinging too hard and losing balance.
- Starting the downswing with the arms instead of the lower body.
- Forgetting to look around before swinging.

Make it a game • Double Pendulum Teach-Back. Swing a broomstick slowly outdoors, in clear space, with your parent standing well back. Tell your parent what each part of the double pendulum is doing at the backswing, downswing and finish. Parent plays the student and asks one question about the kinetic chain. Then do three swings in balance and hold the finish for three seconds.

Scripture. “Brethren, I count not myself to have apprehended: but this one thing I do, forgetting those things which are behind, and reaching forth unto those things which are before, I press toward the mark for the prize of the high calling of God in Christ Jesus.” (Philippians 3:13-14, KJV)

Golfers learn to forget the last bad shot and give full attention to the next one. Paul uses the same picture for the Christian life.

UNIT 4

GOLF

Golf grew up on the windy seaside links of Scotland, where the town of St Andrews has been called the home of golf. In this unit you will meet Old Tom Morris, who played, built clubs and balls and cared for the Old Course for nearly forty years, and Harry Vardon, whose famous grip is still used by most golfers today. You will learn why the golf ball changed from stuffed leather to rubber to the dimpled ball we know.

Then you will learn the body mechanics of golf: a good grip and stance, a putting stroke that swings like a pendulum, and a full swing that uses the kinetic chain. You will build a putting course in your house and practice the full swing outdoors with a broomstick or a plastic club, safely, with an adult watching.

PREREQUISITES

- Knows the pendulum and what changes its swing (Lesson 2.3)
- Knows the kinetic chain (Lesson 1.3) and the athletic stance (Lesson 1.2)
- Can measure in centimeters and find an average

MASTERY CHECKLIST

- ☐ I can tell the story of Old Tom Morris and how the golf ball changed.
- ☐ I can hold a club with the Vardon (overlapping) grip and take a balanced stance.
- ☐ I can make a pendulum putting stroke and control distance with the length of the backstroke.
- ☐ I can explain the full swing as a kinetic chain and swing safely outdoors.
- ☐ I can design and play a household putting course and keep score.

OPTIONAL BOOKS AND GAMES FOR THIS UNIT

- **Harry Vardon, The Complete Golfer (1905):** Free on Project Gutenberg. Vardon's own book on the grip, stance and swing, with his photographs. Older language; best for ages 11 and up or read aloud by a parent. Fits Lessons 4.2 and 4.4.
- **U.S. Kids Golf:** Information on junior clubs sized to a child's height and on junior golf programs. Not needed for this unit, which uses a broomstick or plastic club. A parent should preview it.

Not required. Every project in this unit works without them. School Launch has no ties to these authors, publishers or companies.

LESSONS IN THIS UNIT

4.1	Old Tom Morris and St Andrews	2 sessions of 45 minutes
4.2	Grip and Stance: Vardon's Grip	2 sessions of 45 minutes
4.3	The Pendulum Putt	2 sessions of 45 minutes
4.4	The Full Swing with a Broomstick	2 sessions of 45 minutes

UNIT 4 REVIEW

Answer each question in complete sentences. Show your work for the calculation.
The review is worth 50 points.

1. **5 pts**
Who was Old Tom Morris? Give three facts about him.
2. **5 pts**
Why did the gutta-percha ball replace the feathery?
3. **5 pts**
What do dimples do for a golf ball?
4. **5 pts**
Describe the Vardon (overlapping) grip and tell why it helps.

5. (5 pts)

Describe a good golf stance.

6. (5 pts)

In putting, how do you make the ball roll farther without changing your rhythm?

7. (5 pts)

What does a Stimpmeter measure, and why is it a fair test?

8. (5 pts)

A 20 cm backstroke rolls a ball 2 m. A 40 cm backstroke rolls it 5 m. Estimate the backstroke for a 3.5 m putt.

9. (5 pts)

What would happen if a golfer released the wrists too early in the downswing?

10. (5 pts)

Give three safety rules for swinging a club or broomstick.

ANSWER KEY

1. Any three: born in St Andrews in 1821; apprentice to Allan Robertson; won the Open four times (1861, 1862, 1864, 1867); oldest Open champion at 46; Keeper of the Green at St Andrews from 1864 to 1903; father of Young Tom.
2. Gutties were cheaper, tougher, quicker to make and did not fall apart when wet, so more people could play.
3. They help air flow hug the ball so the wake is smaller and there is less drag, and with backspin they help lift the ball, so it flies higher and farther.
4. The little finger of the lower hand rests on top of the gap between the first two fingers of the top hand. It joins the hands so they work as one unit and do not twist the clubface.
5. Feet about shoulder-width apart, knees flexed, bending from the hips with a straight back, weight balanced over the feet.
6. Make a longer backstroke; the putter swings like a pendulum, and a higher backswing makes it move faster at the bottom.
7. Green speed. The same ramp, the same height and the same ball are used every time, so only the green changes.
8. About 30 cm, halfway between, then test and adjust.
9. The club would reach its top speed before the ball, so the clubhead would be slowing down at impact and the shot would be weaker (and often hit fat or thin).
10. Any three: swing only outdoors; keep a clear circle; an adult watches; look around before every swing; never swing toward people, windows or cars; use plastic or foam balls.

PORTFOLIO PIECE: THE FAMILY PUTTING OPEN

Host a putting tournament on your household course (rebuilt or improved from Lesson 4.3) with at least three family members. Prepare a printed course map with each hole's length and par, a scorecard for each player, and a one-page "Rules of the Course" sheet, including safety rules and one rule about honest scoring. Before play, give a two-minute lesson on the pendulum putt. Afterward, post the results and write a short reflection: Which holes were hardest, and how would you redesign one of them?

LOOK FOR	WHAT IT MEANS
Course design	Nine holes with measured lengths, sensible pars and at least one bank shot and one break.
Teaching	The two-minute lesson correctly explains the pendulum stroke and distance control.
Records	Scorecards are complete and totals and comparisons with par are correct.
Reflection	The reflection names a hard hole and gives a specific redesign with a reason.

UNIT 5

VOLLEYBALL

In the winter of 1895, a YMCA teacher in Holyoke, Massachusetts, named William G. Morgan invented a new indoor game for businessmen who wanted exercise without the bumping and crashing of basketball. He called it mintonette. Today we call it volleyball, and it is played by millions of people in gyms, backyards and church halls all over the world.

In this unit you will learn the history of Morgan's game and the body mechanics of its three main skills: the forearm pass, which works by bouncing the ball off a flat platform at the right angle; the set, which uses soft hands to catch and push the ball in one smooth motion; and the serve, in which you hit through the ball. A balloon is the perfect practice ball, because it moves slowly enough for you to get your body in the right place.

PREREQUISITES

- Knows the athletic stance and the split step (Lessons 1.2 and 3.2)
- Knows that the angle of a racket face decides the direction of the ball (Lesson 3.3)
- Knows the pendulum swing (Lesson 2.3)

MASTERY CHECKLIST

- ☐ I can tell the story of William G. Morgan and the beginning of volleyball in 1895.
- ☐ I can make a forearm pass with a flat platform and explain how its angle aims the ball.
- ☐ I can set a balloon or soft ball with soft hands from a triangle window above my forehead.
- ☐ I can make an underhand serve that hits through the ball toward a target.
- ☐ I can practice volleyball skills safely at home and keep a tally of good contacts.

OPTIONAL BOOKS AND GAMES FOR THIS UNIT

- **USA Volleyball**: The national governing body's site, with information on youth volleyball and coaching resources. Fits the whole unit. A parent should preview it.
- **International Volleyball Hall of Fame**: The Hall of Fame in Holyoke, Massachusetts, where Morgan invented the game, with information on the sport's history. Fits Lesson 5.1.

Not required. Every project in this unit works without them. School Launch has no ties to these authors, publishers or companies.

LESSONS IN THIS UNIT

5.1 Morgan's Game: Holyoke, 1895	2 sessions of 45 minutes
5.2 The Forearm Pass with a Balloon	2 sessions of 45 minutes
5.3 The Set	2 sessions of 45 minutes
5.4 The Serve: Hit Through the Ball	2 sessions of 45 minutes

UNIT 5 REVIEW

Answer each question in complete sentences. Show your work for the calculation.
The review is worth 50 points.

1. **5 pts**
Who invented volleyball, where, and in what year?
2. **5 pts**
Why did Morgan invent a new game instead of using basketball?
3. **5 pts**
What was the game's first name, and who suggested the name volley ball?
4. **5 pts**
What decides where a forearm pass goes?

5. (5 pts)

What would happen if a passer swung her arms hard at every ball?

6. (5 pts)

Describe the window used for setting.

7. (5 pts)

Explain “soft hands” using the word time.

8. (5 pts)

Why should a server “hit through” the ball?

9. (5 pts)

You make 15 of 20 serves. What is your serving percentage?

10. (5 pts)

Name the usual three touches in a team’s play and what each one does.

ANSWER KEY

1. William G. Morgan, at the YMCA in Holyoke, Massachusetts, in 1895.
2. Many of the businessmen in his classes found basketball too rough and tiring; he wanted an indoor game with plenty of exercise but no bumping or crashing.
3. Mintonette. Alfred Halstead suggested “volley ball” in 1896 after watching the players volley the ball.
4. Mainly the angle of the platform: the ball bounces off at about the same angle it came in, like light off a mirror.
5. The passes would fly off in many directions and too far, because the swing adds an uncontrolled push; a still, angled platform is more accurate.
6. Thumbs and first fingers form a triangle above the forehead, with fingers spread, so the ball meets the finger pads.
7. Letting the fingers and wrists give makes the stopping of the ball take longer, so the force at each moment is smaller and the ball is easier to control.
8. Keeping the hand moving through contact makes a steadier push in the direction of the target, so the serve is more accurate.
9. $15 \div 20 = 0.75$; $0.75 \times 100 = 75$ percent.
10. Pass (usually a forearm pass to control the ball), set (an overhead pass to put the ball up near the net), attack (a hit over the net to score).

PORTFOLIO PIECE: BACKYARD VOLLEYBALL SKILLS CHART

Make a one-page skills chart for the three volleyball skills: the forearm pass, the set and the underhand serve. For each, include a labeled drawing or photo of yourself, three coaching cues in your own words, and your before-and-after numbers from the projects (passing percentage, sets to target, serving percentage). Then run a 20-minute family volleyball practice with a balloon or beach ball, teaching each skill, and add a short note on what your family found hardest.

LOOK FOR	WHAT IT MEANS
Correct technique	Each drawing or photo shows the skill correctly with accurate cues (flat platform, window, follow-through).
Honest data	The chart includes real numbers from the projects, with percentages calculated correctly.
Physics explained	Each skill includes one sentence explaining the physics: angle, soft hands or hitting through.
Family practice	A safe practice was run and the note describes what was hard and what helped.

5.1 MORGAN'S GAME: HOLYOKE, 1895

OBJECTIVES

- Tell the story of William G. Morgan and the invention of volleyball at the Holyoke YMCA in 1895.
- Explain how Morgan designed a game that was active but gentle on the body.
- Play a balloon version of the first game and write your own rules for it.

Warm-up. Tie a string between two chairs at about the height of your head. With a partner, tap a balloon back and forth over it without catching it. How many hits can you make in a row? What rules would make this into a real game?

WATCH

9th February 1895: Volleyball invented by William G. Morgan

HistoryPod · 2:32

<https://www.youtube.com/watch?v=EclLnVJ1rlw>

WHEN TO WATCH

After the story. This short history uses old photographs of the Holyoke YMCA and Morgan's first rules. Listen for the game's first name.

BACKUP VIDEO

History of Volleyball at YMCA

YMCA Europe · 1:44

https://www.youtube.com/watch?v=Ya_F2Y3m2ic

A short film from the YMCA about how volleyball began and spread.

KEY TERMS

YMCA

The Young Men's Christian Association, founded in London in 1844 to help young men grow in body, mind and spirit.

mintonette

Morgan's first name for volleyball, borrowed partly from badminton.

volley

To hit a ball before it touches the ground.

rally

A series of hits back and forth over the net that ends when the ball touches the floor or goes out.

CORE IDEAS

The story. William G. Morgan studied at the YMCA training school in Springfield, Massachusetts, where he met James Naismith, the teacher who had invented basketball there in 1891. In 1895 Morgan became physical director of the YMCA in nearby Holyoke. Many of the men in his classes were businessmen, some of them older, who found basketball too rough and tiring. Morgan wanted a game they could play indoors in winter, with plenty of exercise but no tackling or crashing into one another. He borrowed ideas from tennis, handball, baseball and basketball, put up a tennis net about 6 feet 6 inches high in the gym, and had the players bat a ball back and forth over it with their hands. He called it **mintonette**.

How they figured it out. Morgan tried several balls. A basketball was too heavy and hard; the rubber bladder from inside a basketball was too light and slow. Before long the A. G. Spalding company was making a special ball for the game, lighter and softer than a basketball. In 1896 Morgan's men showed the game at a YMCA conference in Springfield. A teacher named Alfred Halstead watched the players volleying the ball back and forth and suggested a better name: **volley ball**. The YMCA printed the rules and carried the game across America and around the world. It became an Olympic sport in 1964.

The physics. Morgan's game is gentle because the net keeps the teams apart, so there is no collision between players. Every hit is short: the ball touches a player only for a moment, and players may not catch or hold it. In that short contact, the hands or arms change the ball's direction and speed. A light ball that floats slowly through the air gives players time to move under it. That is also why a balloon is a good practice ball: it moves even more slowly, so you can learn where to stand before you learn to react fast.

On the field. Today a team has six players on each side of the net, and a team may touch the ball up to three times before sending it over: usually a pass, a set and an attack. Players rotate to new positions during the game, so everyone serves and everyone plays in the front and back rows. Volleyball is still played in YMCAs,

schools and backyards, and families can play it with any light ball and a rope between two trees.

PICTURE STUDY



William G. Morgan, Unknown photographer, About 1895 · Photograph · Holyoke, Massachusetts
Image: [Wikimedia Commons](#), public domain

This portrait shows William G. Morgan as a young man, about the time he was physical director of the Holyoke YMCA and invented volleyball. He was about twenty-five years old.

Look closely

- Look at how he is dressed. How is it different from what a gym teacher would wear today?
- Look at his face. What words would you use to describe him?
- Imagine him in the gym. What would he need to set up a new game?

Talk about it

1. Morgan designed a game for men who were not young or strong. How can a game be made safe and fun for many kinds of players?
2. Why do you think the YMCA, a Christian organization, cared about exercise and games?
3. If you could invent a new game for your family, what would you borrow from other games?

Safety first. Play balloon games in a clear room, away from lamps, windows and stairs, with the string at a height that no one can run into. Keep broken balloon pieces away from small children and pets.

PROJECT

Mintonette Day

You will play balloon mintonette, test how the height of the net changes the game, and write and test your own rules.

You will need

- Balloons and a soft, light ball (a beach ball works well)
- String or rope and two chairs or posts
- Masking tape to mark court lines
- A tape measure, at least one partner and the scorebook

Steps

1. Make a court about 3 meters wide and 6 meters long, with a string “net” across the middle. Mark the lines with tape.
2. **Predict.** Will a low net (waist high) or a high net (just above head height) make longer rallies?
3. Play five rallies with the net waist high. Count the hits in each rally.
4. Raise the net just above your head and play five more rallies. Count again.
5. Find the average rally length for each height.
6. Write a set of six simple rules for your family mintonette: how you serve, how many touches each side may have, what counts as out, how you score, how far apart players stand, and one safety rule.
7. Play a game to 11 points using your rules. Afterward, write which rule you would change and why.

Tips

- Tap the balloon up first so you have time to move under it.
- Call “Mine!” when you go for the ball so players do not bump into each other.

Check your work

- ☐ I measured rally lengths at two net heights.
- ☐ I wrote six clear rules including a safety rule.

- ☐ I played a game with my rules and suggested one improvement.

SCOREBOOK

1. Draw your court from above with the net, the lines and where each player stands.
2. Record your rally table for both net heights.
3. Copy your six rules neatly, the way Morgan's first rules were printed.

From history. Morgan's first rules let a team have as many touches as it liked and divided the game into nine innings, a bit like baseball. Over the years the rules changed to three touches per side and rally scoring. Holyoke is now home to the International Volleyball Hall of Fame.

COMMON MISTAKES

- Catching and throwing the ball instead of hitting it.
- Everyone running for the same ball. Call it first.

Make it a game • Morgan's Mix-Up. Tell your parent the story of Holyoke in 1895 in five sentences, but sneak in one wrong fact about William Morgan, mintonette or the YMCA. Your parent listens and rings an imaginary bell when they catch it. Then swap. Add a bonus for explaining why the game was gentle on the body.

Scripture. "For bodily exercise profiteth little: but godliness is profitable unto all things, having promise of the life that now is, and of that which is to come." (1 Timothy 4:8, KJV)

Paul says exercise does profit a little, and the YMCA's founders agreed: a healthy body is worth caring for. But godliness is worth even more.

5.2 THE FOREARM PASS WITH A BALLOON

OBJECTIVES

- Make a forearm pass with a flat platform, using the legs instead of swinging the arms.
- Explain how the angle of the platform aims the ball, like a mirror reflecting light.
- Record passes to a target and improve the percentage of good passes.

Warm-up. Hold a flat book with both hands, tilted toward a wall. Drop a small soft ball onto it from above. Where does the ball go? Change the tilt and try again. Can you make the ball bounce into a laundry basket?

WATCH

Forearm pass | Volleyball

SIKANA English • 1:33

https://www.youtube.com/watch?v=siDVtYyRG_M

WHEN TO WATCH

After the physics paragraph. Watch how the player moves his feet first and angles his platform toward the target.

KEY TERMS

forearm pass

Also called a bump: hitting the ball off the flat inside of both forearms, held together below the waist.

platform

The flat surface made by both forearms held together, with the elbows straight and the thumbs side by side.

angle of reflection

The angle at which a ball bounces off a flat surface; it mirrors the angle at which the ball came in.

passing percentage

Good passes divided by total passes, times 100.

CORE IDEAS

The story. In Morgan's early game, players hit the ball with one or both open hands. As the game spread through YMCAs, schools and military camps in the early 1900s, the ball came over the net harder and faster, and open hands were not always enough to control it. Players began to use the inside of their forearms, held together,

as a broad, flat surface. By the middle of the 20th century, the **forearm pass**, or “bump,” had become the most important way to receive a serve or a hard hit.

How they figured it out. Coaches noticed that players who swung their arms at the ball sent it flying in all directions, while players who held a still, flat platform and let the ball bounce off it passed accurately. The secret was to aim the platform, not swing it. The best passers moved their feet to get behind the ball, bent their knees, angled their arms toward the target and used a little lift from their legs to give the ball height.

The physics. A ball bouncing off a flat surface acts a lot like light bouncing off a mirror: it leaves at about the same angle it came in, measured from a line straight out from the surface. So the direction of your pass is set mostly by the **angle of your platform**, the same way the racket face aimed the tennis ball in Lesson 3.3. A flat, still platform gives a predictable bounce. If your arms are bent or apart, the surface is bumpy and the ball shoots off sideways. A hard ball needs only a still platform; a slow ball needs a little extra push, which should come from your legs, because they are steadier than swinging arms.

On the field. Coaches say “angle your platform to the target” and “get your feet there first.” Good passers move to the ball so that it meets them in the middle of the body, then hold the platform still and finish with their arms pointing at the target. The first pass decides much of what happens next, because a good pass lets the setter make a good set. Practicing with a balloon lets you get your feet in place and see the angle work slowly.

PICTURE STUDY



Girls Playing Volley Ball at Pine Tree Camp, Unknown photographer, Early 20th century · Photograph · Pocono Pines, Pennsylvania; Library of Congress

Image: [Wikimedia Commons](#), public domain

Volleyball spread quickly to summer camps, schools and playgrounds in the early 1900s, because it needed only a net and a ball and could be played by many children at once. This photograph shows girls at a summer camp in the Pocono Mountains of Pennsylvania.

Look closely

- Count the players. Are there more on each side than in a team today?
- Find a girl who is about to hit the ball. Are her knees bent? Where are her arms?
- Look at the ground. How would grass change the way players move?

Talk about it

1. Why would volleyball be a good game for a camp with many children?
2. If the ball came to you low and fast, what part of your arms would you use, and how would you aim it?
3. What would change if the players kept their feet still instead of moving to the ball?

Safety first. Pass balloons or a beach ball indoors, with a clear space around you. Use a soft volleyball trainer outdoors only. Keep your elbows straight but not locked hard, and stop if your forearms get sore.

PROJECT

Passing Percentage

You will practice the forearm pass with a balloon and then a soft ball, measure how often you send the ball to a target, and improve your passing percentage.

You will need

- Balloons and a beach ball or soft volleyball trainer
- A laundry basket, hula hoop or tape square as a target
- A partner to toss, and the scorebook

Steps

1. **Build the platform:** put one hand in the other, thumbs side by side and pointing down, elbows straight. Check that your forearms make a flat surface.
2. **Balloon self-pass:** bump a balloon straight up to yourself as many times as you can without letting it fall. Record your best of three tries.
3. Set the target 3 meters away and to one side of you. Your partner tosses the balloon to you from 3 meters in front.
4. **Predict** your passing percentage out of 20.
5. Pass 20 balloons, turning your platform toward the target. Record each as good (lands in or touches the target) or not.
6. Find your passing percentage: $\text{good passes} \div 20 \times 100$.
7. Switch to the beach ball or soft trainer and pass 20 more. Find the percentage again.
8. Watch your misses. If the ball went too far to one side, change the angle of your platform. Then pass 20 more and compare.

Tips

- Move your feet first so the ball comes to the middle of your body.
- Point your platform at the target and hold it still. Let the ball do the bouncing.

Check your work

- ☐ I made a flat platform with straight elbows.
- ☐ I recorded three sets of 20 passes and calculated each percentage.
- ☐ I changed my platform angle to fix a miss pattern.

SCOREBOOK

1. Draw a ball bouncing off a platform held at three different angles and show where each pass goes.
2. Record your three sets of 20 and your passing percentages.
3. Draw a picture of yourself passing, labeling your knees, platform and target.

From history. Early volleyball nets were lower than today's. Now the net is 2.43 meters (almost 8 feet) high for men and 2.24 meters (about 7 feet 4 inches) for women, and lower for younger players.

COMMON MISTAKES

- Swinging the arms up at the ball.
- Bending the elbows, so the platform is no longer flat.
- Reaching for the ball instead of moving the feet.

Make it a game • Mirror Pass. Pass a balloon to your parent with a flat platform of forearms, bending the legs and not swinging the arms. Your parent holds a pillow at a target spot. Before each pass, say which way to tilt your platform, like a mirror reflecting light. Count your passing percentage out of ten, then try to beat it.

5.3 THE SET

OBJECTIVES

- Make a set with both hands from a triangle window above the forehead.
- Explain how “soft hands” spread the stopping and pushing of the ball over a longer time.
- Set a balloon and a soft ball to a target height and record accuracy.

Warm-up. Have a partner toss you a water balloon or a soft beanbag. First catch it with stiff, straight arms. Then catch it while letting your hands give and move back toward your body. Which catch felt softer? Which was easier?

WATCH

The Basics of Volleyball - Setting

The Art of Coaching Volleyball · 4:00

<https://www.youtube.com/watch?v=HFO3JFaXqQk>

WHEN TO WATCH

After the physics paragraph. A coach teaches young players the hand shape and the setting motion; copy each step with a balloon.

KEY TERMS

set

An overhead pass made with the fingers of both hands, usually to put the ball in the air for a teammate to hit.

window

The triangle shape made by the thumbs and first fingers of both hands, held above the forehead, through which the setter looks at the ball.

soft hands

Fingers and wrists that give a little as the ball arrives and then push it away in one smooth motion.

contact time

How long the ball touches your hands or arms.

CORE IDEAS

The story. In the early 1900s, volleyball spread from the YMCA to colleges, to the playgrounds of big cities, and to the camps of American soldiers during the First World War. In 1916, players in the Philippines began a new style of attack: one player

sent the ball high into the air near the net, and a teammate jumped and struck it down into the other court. Later the rules limited each side to three touches, and the pattern of pass, set and hit became the heart of the game. That middle player, the setter, became the playmaker of the team, like a quarterback in football.

How they figured it out. Setters discovered that the fingers of both hands could control the ball far better than open palms. If the setter shapes the hands into a window above the forehead, catches the ball for an instant on the finger pads, and pushes it out with the arms and legs together, the ball goes exactly where the setter wants it. But the rules say the ball must not be held or thrown, so the contact has to be quick and clean. Coaches learned to watch for spin: a good set barely spins at all, because both hands pushed evenly.

The physics. To stop a moving ball and send it back, your hands must change its motion. If they do it very fast, the force is large and the ball feels hard and may bounce off wildly. If your fingers and wrists **give** a little, the stopping takes longer, so the force at every moment is smaller and the ball is easier to control. That is what coaches mean by **soft hands**. Then the legs and arms straighten together to push the ball up, so the push is even and the ball flies straight without spinning.

On the field. Good setters get under the ball early, square their shoulders to the target, and make the window before the ball arrives. They push with the legs and arms at the same time and finish with arms extended toward the target like a superhero taking off. They practice thousands of sets against a wall and to themselves. A balloon is ideal for learning the window and soft hands, because it is light and slow.

PICTURE STUDY



Volleyball in the Gymnasium, Unknown photographer, Early 1900s · Photograph · A YMCA or school gymnasium in the United States

Image: [Wikimedia Commons](#), public domain

This photograph shows volleyball in an indoor gym in the early 1900s, much like the one where Morgan first taught the game. The teams were larger then, and players wore ordinary gym clothes: shirts and long trousers.

Look closely

- Find the ball. Who is about to play it? Where are his hands?
- Look at how high the net is compared with the players.
- Count how many players are on each side. How is that different from six today?
- Look at the players who are not touching the ball. Are they ready?

Talk about it

1. If you wanted to set the ball for a teammate here, where would you put your hands, and why?
2. Why would a team want one player to be in charge of setting?
3. Why is it important not to catch and throw the ball in volleyball?

Safety first. Set balloons or a light beach ball only. Never set a hard or heavy ball, which can hurt fingers. Keep a clear space above you, away from ceiling fans and lights.

PROJECT

Soft Hands to a Target

You will set a balloon and a soft ball, practice soft hands against a wall, and record how many sets reach a target height and spot.

You will need

- Balloons and a beach ball or very soft trainer ball
- Masking tape to mark a target line on a wall at about 2.5 meters high (or as high as you can safely reach with tape and an adult's help)
- A laundry basket or hoop as a landing target
- A partner and the scorebook

Steps

1. **Make the window:** spread your fingers, touch your thumbs and first fingers to make a triangle, and lift it above your forehead. Look at your partner through it.
2. **Balloon self-sets:** set a balloon straight up over your head, counting how many in a row. Best of three tries.
3. **Wall sets:** stand about 1 meter from a wall and set the soft ball against the wall above the tape line 20 times. Count how many hit above the line and come back to your hands.
4. **Predict:** how many of 20 sets to a partner will land in the target?
5. Your partner tosses the ball to you; you set it to land in the basket 2 meters to your side. Record 20 sets: in, short, long or sideways.
6. Watch for spin. Have your partner tell you after each set whether it spun a lot or a little.
7. Do 20 more sets, working on squaring your shoulders to the target. Compare.

Tips

- Make the window before the ball arrives.
- Push with your legs and arms together, and finish pointing at the target.

Check your work

- ☐ I made a correct window and set with my fingers, not my palms.
- ☐ I recorded wall sets and 40 sets to a target.
- ☐ I noticed and reported spin on my sets.

SCOREBOOK

1. Trace or draw your hands in the window shape.
2. Draw two graphs of force over time: a stiff catch (tall, narrow) and a soft catch (low, wide). Label them.
3. Record your set tallies and write which change helped most.

From history. During and after the First World War, the YMCA sent volleyball equipment and teachers to soldiers and to many countries. That is one reason volleyball became popular so quickly in Europe, Asia and South America.

COMMON MISTAKES

- Hitting the ball with the palms instead of the finger pads.
- Letting the ball drop to the chin before setting it.
- Pushing harder with one hand, which makes the ball spin and drift.

Make it a game • Soft Hands Count. Make a triangle window with your hands above your forehead and set a balloon to a bucket or a chair. Count the hits aloud. Between rounds, explain to your parent why soft hands make the ball stay on the hands longer. Each correct set into the target earns a bean. Collect twelve beans to win.

5.4 THE SERVE: HIT THROUGH THE BALL

OBJECTIVES

- Make an underhand serve with a pendulum arm swing and a firm hand.
- Explain why “hitting through” the ball, with a follow-through toward the target, gives more control.
- Serve a balloon and a soft ball over a net to target zones and record the results.

Warm-up. Hold a soft ball in your left hand (right hand if you are left-handed). Gently swing your other arm back and forward like a pendulum without hitting. Now hit the ball off your hand with a short jab, then with a smooth swing that keeps going toward a target. Which sends the ball straighter?

WATCH

Excellent Drills to Develop Your Underhand Serve

Championship Productions • 3:12

<https://www.youtube.com/watch?v=kZFbkbqG7J8>

WHEN TO WATCH

After the physics paragraph. A college coach leads young players through underhand serving drills; watch the arm swing through toward the target.

BACKUP VIDEO

Underhand and overhand serves | Volleyball

SIKANA English • 1:54

<https://www.youtube.com/watch?v=SnG7XJDunzs>

To see the underhand and overhand serves side by side.

KEY TERMS

underhand serve

A serve in which the arm swings below the shoulder like a pendulum and strikes the ball out of the other hand.

follow-through

Letting the arm keep moving toward the target after hitting the ball.

impulse

A push or hit, made larger by a bigger force or by pushing for a longer time.

service zone

The area behind the end line from which a player serves.

CORE IDEAS

The story. In Morgan's first game, each team served three times in each of nine innings, and the server hit the ball with an open hand. If a serve failed, the server was allowed a second try. As the game grew, the rules became stricter: one serve, from behind the line, clean over the net. A good serve could now win points by itself, and players began working on serves that were steady and accurate. Today beginners learn the **underhand serve** first, because it is reliable and uses a simple pendulum swing.

How they figured it out. Coaches saw that beginners who poked or slapped at the ball, stopping the hand at contact, sent it in all directions. Servers who swung smoothly and let their arm keep going toward the target after contact were much more accurate. The coaches' words for this are "hit through the ball." They also noticed that a firm, flat hitting surface, the heel of the hand or a fist with the thumb on top, gave a cleaner contact than loose fingers.

The physics. The arm swing of an underhand serve is a **pendulum** (Lesson 2.3): the shoulder is the pivot, and a longer, higher backswing gives a faster hand at the bottom. When the hand meets the ball, the hit is an **impulse**: how much the ball's motion changes depends on how hard the hand pushes and how long it stays in contact. If you stop your hand at the ball, the contact is short and jerky. If you keep moving through it, the push is steadier and points in the direction your hand is moving, which is toward the target. The follow-through is the visible sign that you hit through.

On the field. Servers use a routine: stand with the opposite foot forward, hold the ball out in front at waist height, look at the target, swing back, step and swing through, and follow through toward the target. Many teams keep track of serving percentage, because a missed serve gives the other team a free point. As players get stronger, they learn the overhand serve, which uses the throwing motion you learned in Lessons 1.3 and 3.4.

PICTURE STUDY



Volleyball Game, Oak Ridge, Ed Westcott, 1947 · Photograph · Oak Ridge, Tennessee; U.S. Department of Energy

Image: [Wikimedia Commons](#), public domain

Ed Westcott was the official government photographer of the new town of Oak Ridge, Tennessee, and he took thousands of pictures of daily life there in the 1940s. In this one, children play volleyball on a simple dirt court with a rope-and-net strung between two posts.

Look closely

- Find the player reaching for the ball. Is he using his hands or his forearms?
- Look at the court. What did these players need to make a game?
- Look at the player near the back. Where would a server stand?

Talk about it

1. On a rough dirt court, why would a steady underhand serve be a good choice?
2. How could these children practice serving without a full team?
3. What does this photograph tell you about why volleyball spread so widely?

Safety first. Serve balloons indoors and soft trainer balls outdoors, never toward people, windows or pets. Make sure everyone on the other side is watching before you serve. Warm up your shoulder with arm circles.

PROJECT

Serving Zones

You will learn the underhand serve with a balloon and then a soft ball, and track how many serves land in three target zones.

You will need

- Balloons and a beach ball or soft volleyball trainer
- A string net between two chairs or posts at head height
- Masking tape or chalk to divide the far side of your court into three zones (left, middle, right)
- A partner and the scorebook

Steps

1. Practice the stance: opposite foot forward, ball held out at waist height in your non-hitting hand, hitting hand in a firm fist or flat heel.
2. Make ten pendulum swings without the ball, finishing with your hand pointing at the target.
3. **Balloon serves:** from 3 meters behind the net, serve ten balloons over the net. Count how many go over.
4. **Predict** your serving percentage with the soft ball from 4 meters.
5. Serve 20 soft balls from 4 meters. Record each serve: over and in a zone (write which), over but out, or into the net.
6. Calculate your serving percentage (serves that land in $\div 20 \times 100$).
7. Now call a zone before each serve (left, middle or right) and serve 15 more. Count how many land in the zone you called.
8. Write what changed when you focused on following through to the target.

Tips

- Do not toss the ball up for an underhand serve; hit it out of your still hand.
- Step toward the target with the opposite foot as you swing.

Check your work

- ☐ I served with a pendulum swing and followed through toward the target.

- ☐ I recorded 20 serves and calculated my serving percentage.
- ☐ I called zones and recorded 15 aimed serves.

SCOREBOOK

1. Draw the underhand serve in three pictures: backswing, contact, follow-through.
2. Draw your court from above and mark where each of your serves landed with a dot.
3. Record your serving percentage and your called-zone results.

From history. The overhand “floater” serve, hit with no spin so that it wobbles unpredictably through the air, became popular in the mid-1900s. Like a knuckleball in baseball, it is hard to pass because the air pushes it first one way and then another.

WORKED EXAMPLES

Example 1. In practice you serve 25 times and 18 serves land in. What is your serving percentage?

Show solution

1. Divide the good serves by the total: $18 \div 25 = 0.72$.
2. Multiply by 100 to make a percentage: $0.72 \times 100 = 72$.

Answer: 72 percent.

COMMON MISTAKES

- Tossing the ball up instead of hitting it from a still hand.
- Stopping the arm at contact instead of following through.
- Looking at your hand instead of the ball.

Make it a game • Zone Serve Showdown. Mark three service zones on the floor with paper: near, middle and far. Call your zone before each underhand serve with a balloon or a soft ball, then serve with a pendulum swing and follow through. Hitting the called zone earns two points; any other zone earns one. Say why hitting through the ball helps control. Play to twenty.

UNIT 5

VOLLEYBALL

In the winter of 1895, a YMCA teacher in Holyoke, Massachusetts, named William G. Morgan invented a new indoor game for businessmen who wanted exercise without the bumping and crashing of basketball. He called it mintonette. Today we call it volleyball, and it is played by millions of people in gyms, backyards and church halls all over the world.

In this unit you will learn the history of Morgan's game and the body mechanics of its three main skills: the forearm pass, which works by bouncing the ball off a flat platform at the right angle; the set, which uses soft hands to catch and push the ball in one smooth motion; and the serve, in which you hit through the ball. A balloon is the perfect practice ball, because it moves slowly enough for you to get your body in the right place.

PREREQUISITES

- Knows the athletic stance and the split step (Lessons 1.2 and 3.2)
- Knows that the angle of a racket face decides the direction of the ball (Lesson 3.3)
- Knows the pendulum swing (Lesson 2.3)

MASTERY CHECKLIST

- ☐ I can tell the story of William G. Morgan and the beginning of volleyball in 1895.
- ☐ I can make a forearm pass with a flat platform and explain how its angle aims the ball.
- ☐ I can set a balloon or soft ball with soft hands from a triangle window above my forehead.
- ☐ I can make an underhand serve that hits through the ball toward a target.
- ☐ I can practice volleyball skills safely at home and keep a tally of good contacts.

OPTIONAL BOOKS AND GAMES FOR THIS UNIT

- **USA Volleyball**: The national governing body's site, with information on youth volleyball and coaching resources. Fits the whole unit. A parent should preview it.
- **International Volleyball Hall of Fame**: The Hall of Fame in Holyoke, Massachusetts, where Morgan invented the game, with information on the sport's history. Fits Lesson 5.1.

Not required. Every project in this unit works without them. School Launch has no ties to these authors, publishers or companies.

LESSONS IN THIS UNIT

5.1 Morgan's Game: Holyoke, 1895	2 sessions of 45 minutes
5.2 The Forearm Pass with a Balloon	2 sessions of 45 minutes
5.3 The Set	2 sessions of 45 minutes
5.4 The Serve: Hit Through the Ball	2 sessions of 45 minutes

UNIT 5 REVIEW

Answer each question in complete sentences. Show your work for the calculation.
The review is worth 50 points.

1. **5 pts**
Who invented volleyball, where, and in what year?
2. **5 pts**
Why did Morgan invent a new game instead of using basketball?
3. **5 pts**
What was the game's first name, and who suggested the name volley ball?
4. **5 pts**
What decides where a forearm pass goes?

5. (5 pts)

What would happen if a passer swung her arms hard at every ball?

6. (5 pts)

Describe the window used for setting.

7. (5 pts)

Explain “soft hands” using the word time.

8. (5 pts)

Why should a server “hit through” the ball?

9. (5 pts)

You make 15 of 20 serves. What is your serving percentage?

10. (5 pts)

Name the usual three touches in a team’s play and what each one does.

ANSWER KEY

1. William G. Morgan, at the YMCA in Holyoke, Massachusetts, in 1895.
2. Many of the businessmen in his classes found basketball too rough and tiring; he wanted an indoor game with plenty of exercise but no bumping or crashing.
3. Mintonette. Alfred Halstead suggested “volley ball” in 1896 after watching the players volley the ball.
4. Mainly the angle of the platform: the ball bounces off at about the same angle it came in, like light off a mirror.
5. The passes would fly off in many directions and too far, because the swing adds an uncontrolled push; a still, angled platform is more accurate.
6. Thumbs and first fingers form a triangle above the forehead, with fingers spread, so the ball meets the finger pads.
7. Letting the fingers and wrists give makes the stopping of the ball take longer, so the force at each moment is smaller and the ball is easier to control.
8. Keeping the hand moving through contact makes a steadier push in the direction of the target, so the serve is more accurate.
9. $15 \div 20 = 0.75$; $0.75 \times 100 = 75$ percent.
10. Pass (usually a forearm pass to control the ball), set (an overhead pass to put the ball up near the net), attack (a hit over the net to score).

PORTFOLIO PIECE: BACKYARD VOLLEYBALL SKILLS CHART

Make a one-page skills chart for the three volleyball skills: the forearm pass, the set and the underhand serve. For each, include a labeled drawing or photo of yourself, three coaching cues in your own words, and your before-and-after numbers from the projects (passing percentage, sets to target, serving percentage). Then run a 20-minute family volleyball practice with a balloon or beach ball, teaching each skill, and add a short note on what your family found hardest.

LOOK FOR	WHAT IT MEANS
Correct technique	Each drawing or photo shows the skill correctly with accurate cues (flat platform, window, follow-through).
Honest data	The chart includes real numbers from the projects, with percentages calculated correctly.
Physics explained	Each skill includes one sentence explaining the physics: angle, soft hands or hitting through.
Family practice	A safe practice was run and the note describes what was hard and what helped.

BASEBALL AND SOFTBALL

Baseball and softball are full of body mechanics: the throw, the catch, the swing and the pitch. In this unit you will meet Walter Johnson, whose smooth, whip-like delivery made him one of the greatest pitchers ever; Gabby Street, who caught a baseball dropped from the top of the Washington Monument; Babe Ruth, who learned to hit from a teacher at his boyhood school; and Candy Cummings, who said he learned to throw a curveball by tossing clamshells on a beach.

You will learn to throw with your whole body, to catch “soft” by letting your hands give with the ball, to swing level with a foam bat, and to see why a spinning ball curves. Every drill uses soft balls, foam bats and rolled-up socks, with swinging done outdoors and an adult watching.

PREREQUISITES

- Knows the kinetic chain and the order of a good throw (Lesson 1.3)
- Knows that soft hands spread a catch over a longer time (Lesson 5.3)
- Knows the athletic stance (Lesson 1.2)

MASTERY CHECKLIST

- ☐ I can throw with my whole body: step, turn, arm and follow-through.
- ☐ I can catch soft by reaching out and letting my hands give with the ball, and explain why that works.
- ☐ I can swing a foam bat level through the hitting zone and meet the ball out in front.
- ☐ I can explain why a spinning ball curves (the Magnus effect) and show it with a ball and a paper tube.
- ☐ I can follow the safety rules for throwing, catching and swinging.

OPTIONAL BOOKS AND GAMES FOR THIS UNIT

- **MLB Pitch Smart:** Free guidelines from Major League Baseball and USA Baseball on pitch counts and rest days for young pitchers, by age. Parents should read it before any pitching practice. Fits Lessons 6.1 and 6.4.
- **Little League:** Information on youth baseball and softball, including rules and safety. A parent should preview it.

Not required. Every project in this unit works without them. School Launch has no ties to these authors, publishers or companies.

LESSONS IN THIS UNIT

6.1	Throwing with the Whole Body	2 sessions of 45 minutes
6.2	Catching Soft	2 sessions of 45 minutes
6.3	The Level Swing	2 sessions of 45 minutes
6.4	Why Curveballs Curve	2 sessions of 45 minutes

UNIT 6 REVIEW

Answer each question in complete sentences. Show your work for the calculation. You may stand up and show a movement. The review is worth 50 points.

1. **5 pts**
List the five steps of a whole-body throw in order.
2. **5 pts**
Why is a whole-body throw safer for the arm than an arm-only throw?
3. **5 pts**
What would happen if a young pitcher threw many more pitches than the league's pitch count allows, day after day?
4. **5 pts**
What did Gabby Street do on August 21, 1908?

5. (5 pts)

Explain soft hands using the words force and time.

6. (5 pts)

A stiff catch stops a ball in 0.02 seconds and a soft catch in 0.08 seconds. How many times smaller is the average force with the soft catch?

7. (5 pts)

Why does a level swing give a batter a better chance to hit the ball?

8. (5 pts)

What is the sweet spot of a bat, and how can you tell when you hit it?

9. (5 pts)

Who taught young George Ruth to play baseball, and where?

10. (5 pts)

Explain the Magnus effect in your own words and give one example from a sport.

ANSWER KEY

1. Stand sideways and point the glove at the target; step toward the target with the opposite foot; turn the hips and shoulders; bring the arm through with the elbow about shoulder height; follow through across the body.
2. The big muscles of the legs and trunk do most of the work and speed up the arm, so the small muscles of the shoulder and elbow do not have to strain.
3. The arm would get tired and overused, and he would be much more likely to hurt his elbow or shoulder.
4. He caught a baseball dropped from near the top of the Washington Monument, about 555 feet up, on his thirteenth try.
5. Giving with the ball makes the stop take longer, so the force at each moment is smaller; the catch stings less and the ball does not bounce out.
6. $0.08 \div 0.02 = 4$, so the force is 4 times smaller.
7. The bat travels along the path of the ball for longer, so there are more moments when it can meet the ball, instead of one tiny moment with a steep swing.
8. The place on the barrel, a few inches from the end, where the ball jumps off best; the bat barely vibrates and your hands feel little sting.
9. Brother Matthias Boutilier, at St. Mary's Industrial School for Boys in Baltimore.
10. A spinning ball throws air off to one side, so the air pushes the ball the other way and it curves. Examples: a curveball, a bending soccer free kick, topspin in tennis, a golf slice.

PORTFOLIO PIECE: A BACKYARD BASEBALL SKILLS CIRCUIT

Design a four-station baseball and softball skills circuit for your family: a throwing station (point, step and throw at a target), a catching station (soft hands with a beanbag or water balloon), a hitting station (tee work with a foam bat) and a spin station (curve a light ball with a tube or a spinning throw). For each station, make a sign with the instructions, the safety rule and a scorecard. Run the circuit with at least two family members, keep their scores, and write one paragraph on what each person improved.

LOOK FOR	WHAT IT MEANS
Clear stations	Each station has a sign with correct instructions, a safety rule and a way to score.
Physics explained	Each sign includes one sentence of physics: kinetic chain, impulse, level swing or Magnus effect.
Safe running	The circuit was run safely, with swinging outdoors and an adult present.
Records	Scores are recorded for each player, with a short paragraph on improvement.

6.1 THROWING WITH THE WHOLE BODY

OBJECTIVES

- Show a good overhand throw: sideways start, step toward the target, hip and shoulder turn, arm, release and follow-through.
- Explain why a whole-body throw is faster and easier on the arm than an arm-only throw.
- Measure throwing accuracy at a target before and after practice.

Warm-up. Stand facing a target 5 meters away and throw a soft ball five times without moving your feet. Then turn sideways, point your glove hand at the target, step toward it and throw five more. Which way hit the target more often? Which felt easier on your arm?

WATCH

Teaching Beginners How To Throw A Baseball

Northern Baseball Training • 3:08

<https://www.youtube.com/watch?v=eXuXBj-xbB8>

WHEN TO WATCH

After the physics paragraph. A coach shows the throwing motion step by step; watch the order: feet, hips, shoulders, arm.

BACKUP VIDEO

How to Teach Young Kids to Throw [Step-by-Step]

Coach Dan Blewett • 16:27

https://www.youtube.com/watch?v=R0A_qFdt5jY

For parents and older students: a coach's step-by-step way of teaching young players to throw.

KEY TERMS

stride

The step toward the target with the foot opposite the throwing arm.

release point

The place where the ball leaves the hand: out in front of the body, above the shoulder for an overhand throw.

follow-through

Letting the throwing arm keep going across the body after release, so it slows down gently.

pitch count

The number of pitches a pitcher has thrown in a game; youth leagues set limits to protect young arms.

CORE IDEAS

The story. Walter Johnson grew up on a farm in Kansas and in the oil fields of California. He had long arms and an easy, sweeping sidearm motion that looked almost lazy, yet his fastball was the fastest of his day. He pitched for the Washington Senators from 1907 to 1927 and won 417 games, still the second most of all time, with 110 shutouts, still the record. Batters said they could hardly see the ball. He was also known as a gentleman: he rarely argued with umpires and was careful never to throw at batters. In 1936 he was one of the first five players chosen for the Baseball Hall of Fame.

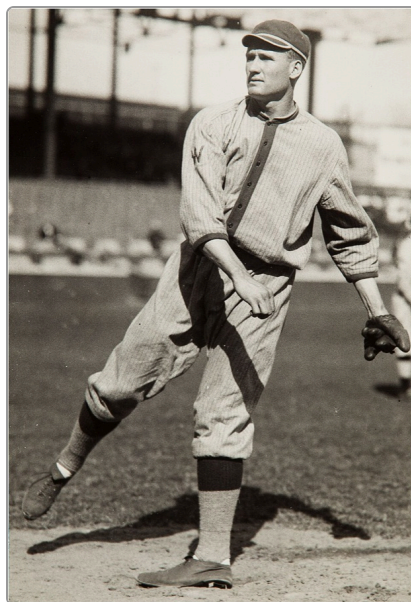
How they figured it out. People who watched Johnson said his speed seemed to come from his whole body, not from muscling the ball with his arm. Years later, scientists filmed pitchers at high speed and measured each part of the body. They found that a good throw starts with the stride and the legs, then the hips turn, then the trunk and shoulders, then the elbow and finally the wrist and fingers. Each part speeds up the next, like the whip and the line of boys in Snap the Whip (Lesson 1.3). They also found that young pitchers who throw too many pitches, or who throw with the arm alone, are more likely to hurt their elbows and shoulders. That is why youth leagues now count pitches and require rest days.

The physics. The ball can only be thrown as fast as the hand is moving when it lets go. Your hand moves fastest when every link of the kinetic chain adds its speed in the right order. The stride gives your whole body forward **momentum**. Turning the hips and shoulders adds a spin that whips the arm around. Because the big muscles of the legs and trunk do most of the work, the small muscles of the shoulder and elbow do not have to strain. The follow-through matters too: the arm has a lot of speed after release, and letting it swing across the body slows it down safely instead of stopping it suddenly.

On the field. Coaches teach young players to “point, step and throw”: point the glove at the target, step toward it with the opposite foot, and throw. They watch for an elbow at about shoulder height and a follow-through across the body. They also

follow pitch counts and rest rules strictly. A good thrower is accurate first and fast second. Johnson himself was famous for his control: he could put the ball where he wanted it.

PICTURE STUDY



Walter Johnson, Charles M. Conlon, 1910s · Photograph · New York; Conlon photographed players at the Polo Grounds and other ballparks

Image: [Wikimedia Commons](#), public domain

Charles Conlon was a newspaper proofreader who photographed baseball players as a hobby for more than thirty years. His photographs are some of the best records of how the players of the early 1900s moved. Here he caught Walter Johnson, “the Big Train,” just after a pitch.

Look closely

- Look at his feet. How long is his stride compared with his height?
- Look at his throwing arm. Where is it now, after the pitch? What does that tell you about his follow-through?
- Look at his back leg. How has his weight moved?
- Look at his face and shoulders. Does he look tense or relaxed?

Talk about it

1. Which links of the kinetic chain can you see in this photograph?
2. Johnson pitched for twenty-one years. How might a smooth, whole-body motion have helped his arm last so long?
3. Johnson was known for sportsmanship as well as speed. Why do you think people remembered both?

Safety first. Warm up with arm circles and short, easy throws first. Throw only soft balls or rolled-up socks indoors, and use a soft or rubber ball outdoors. Make sure your partner is ready and watching before you throw. Throw no more than about 30 hard throws in a day, and stop if your arm hurts and tell a parent.

PROJECT

Point, Step and Throw

You will measure your throwing accuracy at a target, learn the whole-body throw in steps, and measure again after three days of practice.

You will need

- Soft balls, tennis balls (outdoors) or rolled-up socks
- A target: a hula hoop hung on a fence, a box, or a tape square on a wall (about 60 cm wide)
- A tape measure and the scorebook
- A partner or parent

Steps

1. Mark a throwing line 6 meters from the target (4 meters for younger students).
2. **Before test:** after warming up, throw 15 balls at the target. Record hits and misses.
3. Learn the throw in steps: (1) stand sideways and point your glove hand at the target; (2) step toward the target with the opposite foot; (3) turn your hips and shoulders; (4) bring your arm through with the elbow at shoulder height; (5) follow through across your body.
4. Do 10 slow-motion throws without a ball, saying each step aloud.
5. Practice for 10 minutes on three different days, throwing to a partner or the target. Each day, pick one step to focus on.
6. **After test:** on the fourth day, throw 15 balls at the target from the same line. Record hits and misses.
7. Compare your before and after accuracy as fractions (hits out of 15) and as percentages.
8. Have someone film or watch one of your throws and check the five steps.

Tips

- Look at the target the whole time, not at your arm.

- Accuracy first. Speed will come as your chain gets smoother.

Check your work

- ☐ I recorded 15 throws before and after practice from the same line.
- ☐ I can show and name the five steps of a whole-body throw.
- ☐ I calculated my accuracy as a percentage both times.

SCOREBOOK

1. Draw a stick figure throwing in five frames, one for each step.
2. Record your before and after accuracy and make a bar graph.
3. Write two rules a youth league uses to protect young pitchers' arms, and why.

From history. Johnson's 110 shutouts (games in which the other team scored no runs) have stood as the major-league record for about a hundred years. After his playing days he managed the Senators and the Cleveland Indians.

COMMON MISTAKES

- Facing the target with the chest at the start, so the hips and shoulders cannot turn.
- Stepping with the same-side foot as the throwing arm.
- Stopping the arm right after release.

Make it a game • Throw Sequence Relay. Lay out five cards on the floor: sideways start, stride, turn, arm, follow-through. Stand on each card in order and show that part of the throw with a soft ball and no release. A parent can mix the cards, and you reorder them in thirty seconds. Then say why whole-body throws are easier on the arm.

6.2 CATCHING SOFT

OBJECTIVES

- Catch a ball with “soft hands,” reaching out and giving with the ball.
- Explain why stopping a ball over a longer time makes a smaller force.
- Test catches of a water balloon or egg-shaped beanbag with stiff and soft hands.

Warm-up. Hold your hands in front of you and have a partner gently toss a beanbag or rolled-up socks. Catch five with stiff arms and hands that do not move. Then catch five while reaching out and letting your hands come back toward your body. Which catches felt softer? Which stayed in your hands?

WATCH

Coaching Beginner Baseball | How to Catch (Pro Speed Baseball)

Pro Speed Baseball • 4:26

<https://www.youtube.com/watch?v=Ohy4hOefDx4>

WHEN TO WATCH

After the physics paragraph. Watch where the young player’s glove starts and how the coach teaches him to give with the ball.

BACKUP VIDEO

The Basics: Catching

Little League • 0:55

<https://www.youtube.com/watch?v=j9AXCjF3CTA>

A short catching lesson from Little League.

KEY TERMS

soft hands

Hands that reach out to meet the ball and then move back with it, stopping it gently.

impulse

The push needed to change an object’s motion; the same impulse can be a big force for a short time or a small force for a longer time.

two hands

Catching with the glove hand and covering the ball with the throwing hand, so it cannot pop out.

tracking

Watching the ball all the way into the glove or hands.

CORE IDEAS

The story. On August 21, 1908, Charles “Gabby” Street, a catcher for the Washington Senators, stood at the foot of the Washington Monument in Washington, D.C. A newspaperman named Preston Gibson, at the top, about 555 feet (169 meters) above the ground, dropped baseballs to him one at a time. The balls fell for several seconds and were moving very fast by the time they reached the ground. Street missed the first twelve. On the thirteenth try, he caught it. Newspapers across the country reported the feat. Street was also the regular catcher for the young Walter Johnson, so he knew all about stopping fast balls.

How they figured it out. Catchers like Street had long known how to handle hard throws: you do not hold your hands stiff and let the ball slam into them. You reach out to meet the ball and then let your hands and arms “ride” back with it. Early catchers used thin gloves or none at all and often broke fingers, so they learned this lesson the hard way. Later, padded catcher’s mitts helped too. Scientists explained why it works with the idea of **impulse**.

The physics. To stop a moving ball, your hands must take away all of its motion. You can do that with a big force in a very short time or a smaller force over a longer time; either way, the total “stopping” is the same. When your hands are stiff, the ball stops in a tiny fraction of a second, so the force is large: it stings and often bounces out. When your hands give, the stop takes longer, so the force at each instant is much smaller. That is why a catcher’s padded mitt, a bicycle helmet’s foam and an air bag in a car all work: they make the stop take longer.

On the field. Coaches tell young players to show “two hands, eyes on the ball, give with it.” Fingers point up for a ball above the waist and down for a ball below the waist. Players reach out toward the ball so there is room to give, and they cover the ball with the throwing hand. Young players start with soft balls so they can learn without fear of being hurt. Never try a high-drop catch like Gabby Street’s; it was dangerous even for a professional catcher with a mitt.

PICTURE STUDY



Gabby Street, Washington, Bain News Service, 1910 · Glass-plate negative · Library of Congress, Prints and Photographs Division

Image: [Wikimedia Commons](#), public domain

The Bain News Service took thousands of photographs of baseball players for newspapers in the early 1900s. This one shows Gabby Street two years after his famous Washington Monument catch, with the thick, round catcher's mitt of his day.

Look closely

- Look at his mitt. How is it different from a fielder's glove today?
- Look at his hands. Are they held out in front of his body or close to it?
- Look at his knees and feet. Is he ready to move?

Talk about it

1. How does a thick, padded mitt make the stop take longer?
2. Why would reaching out in front of your body give your hands more room to give with the ball?
3. Street missed twelve balls before he caught one. What does that tell you about practice and patience?

Safety first. Catch only soft balls, beanbags or water balloons. Start close together and move apart slowly. The thrower tosses gently and only when the catcher says “Ready.” Keep fingers pointed up or down, never straight at the ball. Water-balloon catching is done outdoors.

PROJECT

The Water Balloon Catch

You will test soft hands with water balloons, the ultimate soft-hands test: catch it stiffly and it bursts; catch it softly and it survives. Then you will practice two-hand catching with a soft ball.

You will need

- A bag of small balloons, filled with water outdoors (or beanbags if you must work indoors)
- A soft ball or tennis ball
- A tape measure, a partner and the scorebook

Steps

1. Stand 2 meters apart outdoors.
2. **Predict:** out of 10 stiff-hand catches and 10 soft-hand catches, how many balloons will burst each way?
3. Catch 10 water balloons with stiff hands that do not move. Record catches, drops and bursts.
4. Catch 10 water balloons reaching out and giving with them. Record the same.
5. Step back to 4 meters and repeat the soft-hand catches. Did the longer, faster toss need more give?
6. **Two-hand catching:** with a soft ball, catch 20 throws using two hands. Record clean catches.
7. Write a paragraph explaining your results with the words force, time and give.
8. Pick up every piece of balloon when you are finished.

Tips

- Reach out early so your hands have room to travel back.
- Watch the balloon all the way into your hands.

Check your work

- ☐ I recorded 10 stiff-hand and 10 soft-hand water-balloon catches.
- ☐ I recorded 20 two-hand catches with a soft ball.
- ☐ I explained my results using force and time.

SCOREBOOK

1. Draw a stiff catch and a soft catch side by side, with arrows showing how far the hands move.
2. Record your water-balloon table and two-hand catching tally.
3. List three things in everyday life that make a stop take longer to make it safer (helmets, air bags, a gym mat).

From history. Gabby Street later managed the St. Louis Cardinals to a World Series title in 1931. Other people had tried the Washington Monument catch before him, and later players tried similar catches from tall buildings and even airplanes, but such stunts are dangerous and are not practice drills.

WORKED EXAMPLES

Example 1. A ball takes 0.01 seconds to stop when you catch it with stiff hands and 0.05 seconds when you give with it. How many times smaller is the average force with soft hands?

Show solution

1. The total stopping (impulse) is the same both times.
2. The soft catch takes $0.05 \div 0.01 = 5$ times as long.
3. So the average force is 5 times smaller.

Answer: Five times smaller.

COMMON MISTAKES

- Closing the eyes or turning the head away as the ball arrives.
- Holding the hands close to the chest, so there is no room to give.
- Catching with one hand when two hands are safer.

Make it a game • Give-with-It Quiz. Toss a soft ball or rolled socks for your parent to catch with soft hands, and then reverse roles. Each time the catcher gives with the ball, they say one reason why stopping it over a longer time makes a smaller force. Reasons cannot repeat. The first to run out of reasons loses the round.

6.3 THE LEVEL SWING

OBJECTIVES

- Take a balanced batting stance and swing a foam bat on a level path through the hitting zone.
- Explain why a level swing gives more chances to meet the ball, and what the sweet spot is.
- Hit a soft ball off a tee (or a cone or bucket) and record solid contacts.

Warm-up. Hold a foam bat or a cardboard tube. Ask a partner to hold a ball out to the side at waist height. Swing slowly once with a steep chopping path and once with a long, level path. With which path did the bat stay at the height of the ball longer?

WATCH

Coaching Beginner Baseball | Basic Hitting 4 Easy Steps (Pro Speed Baseball)

Pro Speed Baseball • 6:30

https://www.youtube.com/watch?v=G_n_tlesB-I

WHEN TO WATCH

After the physics paragraph. A coach teaches a young hitter grip, stance, load and stride; copy each step with a foam bat outdoors.

BACKUP VIDEO

Intro To Hitting A Baseball - 5 Easy Steps For Beginners - Swing Basics

Northern Baseball Training • 5:53

<https://www.youtube.com/watch?v=4FxVIX7Lyd0>

A second short lesson on the basic swing for beginners.

KEY TERMS

stance

How a batter stands: feet a little wider than the shoulders, knees bent, weight balanced, hands near the back shoulder.

hitting zone

The part of the swing, out in front of the body, where the bat can meet the ball well.

sweet spot

The place on the barrel of the bat, a few inches from the end, where the ball jumps off best and the hands feel almost no sting.

batting tee

A stand that holds the ball still at the right height, so a batter can practice the swing.

CORE IDEAS

The story. George Herman Ruth grew up in Baltimore and spent much of his boyhood at St. Mary's Industrial School for Boys, a school run by Catholic brothers. One of them, Brother Matthias Boutilier, a tall, strong man, became his teacher and his hero. Brother Matthias hit fly balls to the boys and showed young George how to swing. Ruth later said that Brother Matthias was the greatest man he ever knew. He became "Babe" Ruth, the most famous hitter in baseball history, who hit 60 home runs in 1927 and 714 in his career. All his life he loved visiting children, and he often stopped to show boys how to hold a bat.

How they figured it out. Hitting a baseball is often called the hardest skill in sports. A pitched ball reaches the plate in about half a second, and the batter must decide, swing and meet it with a round bat. Coaches noticed that young batters who chopped down or swung up steeply missed most pitches, while those whose bat moved along the path of the ball for a longer time made contact far more often. Later, scientists measured bats and found the **sweet spot**, the part of the barrel where the ball rebounds best and the bat barely shakes in the hands.

The physics. A pitched ball travels along a line toward you. If your bat moves along that same line for a long stretch, you have many chances to meet the ball; if it cuts across the line steeply, there is only one tiny moment. That is the idea of a **level swing** through the hitting zone. The bat is also a lever turning around your hands and body, so the barrel end moves fastest. Hitting the ball on the **sweet spot** sends the most energy into the ball. Hitting near the handle or the very tip makes the bat vibrate, which stings your hands and wastes energy.

On the field. Coaches teach hitting in steps: a balanced stance; a small step toward the pitcher; a turn of the hips and shoulders; and a swing that brings the bat through the zone with the eyes on the ball, meeting it out in front of the front hip. Young players practice off a tee thousands of times. In softball the ball is larger and the pitch comes underhand, but the swing mechanics are almost the same. At home,

a foam bat and a soft ball on a tee or an upside-down bucket let you practice safely outdoors.

PICTURE STUDY



Babe Ruth Instructs a Boy, Unknown newspaper photographer, 1920s or early 1930s · Photograph · Nicollet Park, Minneapolis, Minnesota
Image: [Wikimedia Commons](#), public domain

Babe Ruth often played exhibition games in towns across America, and he loved spending time with children. Before one game in Minneapolis, a newspaper photographer caught him showing a local boy how to hold the bat.

Look closely

- Look at the boy's hands on the bat. Are they together or apart? Near the knob or up the handle?
- Look at Ruth's hands. What is he correcting?
- Look at the faces. How do you think the boy feels?

Talk about it

1. Why would a good grip be the first thing a coach checks?
2. Ruth was taught by Brother Matthias when he was a boy. Who has taught you a skill, and how did he or she teach it?
3. What could you teach a younger child, the way Ruth taught this boy?

Safety first. Swing bats only outdoors, with a clear circle at least two bat lengths wide and an adult watching. Use a foam or plastic bat and a soft ball. No one stands near the batter; the person who resets the ball waits until the batter has set the bat down. Never let go of the bat.

PROJECT

Tee Work and the Sweet Spot

You will find the sweet spot of a bat, then practice a level swing off a tee and record solid contacts.

You will need

- A foam or plastic bat (a wooden bat for the sweet-spot test only, held by an adult)
- Soft balls or whiffle balls
- A batting tee, or a traffic cone or upside-down bucket with a toilet-paper tube on top
- A small hammer or wooden spoon for tapping
- A tape measure, an adult and the scorebook

Steps

1. **Sweet-spot test:** an adult holds a wooden or plastic bat loosely by the handle with the barrel hanging down. Tap the barrel with a wooden spoon at several places from the end up toward the handle. Find the place where the handle shakes least. Measure how far it is from the end of the bat.
2. **Stance:** outdoors, practice your stance in front of a partner: feet a bit wider than shoulders, knees bent, hands near the back shoulder, eyes level.
3. Make 10 slow, level practice swings without a ball, finishing with your belly button facing the pitcher.
4. Set the tee at about your belt height, a little in front of your front hip.
5. **Predict:** how many of 20 swings will be solid line drives?
6. Hit 20 soft balls off the tee. For each, record: line drive, ground ball, pop-up or miss.
7. Choose one fix (for example, “keep my eyes on the ball,” or “step, then swing”) and hit 20 more. Record the same.
8. Compare your results and write which fix helped.

Tips

- Keep your head still and your eyes on the ball until after contact.
- Swing through the ball to a full finish; do not stop at contact.

Check your work

- ☐ I found and measured the sweet spot of a bat.
- ☐ I recorded 40 swings off a tee in categories.
- ☐ I made one change and compared my results.

SCOREBOOK

1. Draw a level swing path and a steep chopping swing path past a ball, and shade where each could meet the ball.
2. Draw a bat and mark your measured sweet spot.
3. Record your tee-work table and make a bar graph of the kinds of hits.

From history. Ruth began his career as a pitcher, and a very good one, before the Yankees made him an everyday outfielder so he could hit every day. He never forgot St. Mary's, and he helped raise money for the school after a fire there.

COMMON MISTAKES

- Taking your eyes off the ball to see where it went.
- Dropping the back shoulder and swinging up steeply.
- Swinging so hard that you lose your balance.

Make it a game • Level Swing Judge. Swing a foam bat or rolled newspaper at a ball on a stack of books. A parent watches from the side and calls level or not level. Before each swing, name your stance cue and where the sweet spot is. Ten swings, one point for each level swing that meets the ball. Try to beat your best.

Scripture. “Train up a child in the way he should go: and when he is old, he will not depart from it.” (Proverbs 22:6, KJV)

Brother Matthias trained a troubled boy patiently, and that boy remembered him all his life. Good teaching, in sport and in life, is a lasting gift.

6.4 WHY CURVEBALLS CURVE

OBJECTIVES

- Tell the story of Candy Cummings and the first curveballs.
- Explain the Magnus effect: a spinning ball is pushed sideways by the air.
- Make a ball curve on purpose with a paper-tube launcher and a soft ball, and record the curve.

Warm-up. Roll a sheet of paper into a tube and tape it. Put a ping-pong ball or a small foam ball in one end, then swing the tube quickly and let the ball fly out. Does the ball fly straight or curve? Which way does it curve?

WATCH

The Science of Curveballs

Veritasium · 4:07

<https://www.youtube.com/watch?v=t-3jnOIJg4k>

WHEN TO WATCH

After the story. Watch how the spin of the ball changes the push of the air.

KEY TERMS

curveball

A pitch thrown with spin so that it bends as it travels toward the batter.

Magnus effect

The sideways push the air gives a spinning ball, named for the German scientist Gustav Magnus.

spin axis

The imaginary line a spinning ball turns around; it decides which way the ball curves.

wind tunnel

A tunnel where air is blown past an object so scientists can measure how the air pushes on it.

CORE IDEAS

The story. William Arthur “Candy” Cummings grew up in Massachusetts and New York in the 1860s. He later said that as a boy, around 1863, he noticed on a beach in Brooklyn that clamshells he threw curved through the air, and he wondered whether a baseball could be made to do the same. He practiced for years, gripping and spinning the ball in different ways. Pitching for an amateur club in 1867, he said, he

threw a ball that curved away from the batter, and he went on to become a star pitcher. He is honored in the Baseball Hall of Fame, and his plaque calls him the inventor of the curveball, though others also claimed the idea.

How they figured it out. For many years some people insisted that a curveball was only an optical illusion. Pitchers and players set up public tests with posts or stakes in a line and threw balls that went around them. In 1959 a scientist named Lyman Briggs, the former director of the National Bureau of Standards, settled the question with careful measurements. He spun baseballs in a **wind tunnel** and measured the sideways push of the air, and he found that a spinning baseball really can bend more than a foot on its way to the plate. The physics behind it had been explained a century earlier, in 1852, by the German scientist Gustav Magnus, who was studying why spinning cannonballs curved.

The physics. As a ball flies through the air, it pushes the air aside. If the ball is spinning, one side of the ball is moving forward into the air faster than the other side. The spinning surface (and, on a baseball, the raised seams) drags the air around with it, so the air is thrown off toward one side of the ball. The ball pushes the air one way, and the air pushes the ball the other way (Newton's third law). That sideways push is the **Magnus effect**. Topspin makes a ball dive down; backspin holds it up; sidespin makes it curve left or right. The **spin axis** decides the direction.

On the field. Pitchers use spin to make the ball move: the fastball's backspin helps it hold its height, the curveball's topspin makes it drop, and the slider's spin makes it slide sideways. Soccer players bend free kicks, tennis players hit topspin, and golfers fight slices with the same physics. Young pitchers should learn to throw strikes with a good fastball and a change-up first; many youth coaches advise waiting until the arm is more grown before throwing many curveballs, and youth leagues set pitch-count limits.

PICTURE STUDY



Candy Cummings, Unknown photographer, 1872 · Photograph · Probably New York

Image: [Wikimedia Commons](#), public domain

This photograph shows Candy Cummings in 1872, when he was one of the best pitchers in the country. He was small and slender, which shows that his pitching success came from skill and spin rather than size and strength.

Look closely

- Look at his face. How old do you think he is here?
- Look at his clothes. What do they tell you about the 1870s?
- Look at his hands, if you can see them. A pitcher's fingers make the spin. How would you hold a ball to spin it?

Talk about it

1. Cummings said clamshells gave him his idea. What everyday thing have you noticed that might teach you something about sport?
2. Why did it take so long, and a wind tunnel, to convince everyone that curveballs really curve?
3. Cummings was not big or strong. What does his story teach about skill and practice?

Safety first. Throw spinning balls only underhand or gently, with soft or foam balls, in a clear space. Do not practice throwing hard curveballs; save them for when your arm is grown and a coach is teaching you. Launch paper-tube balls away from people and pets.

PROJECT

Make It Curve

You will test the Magnus effect with a paper-tube launcher and a light ball, measure how far the ball curves with and without spin, and then try to curve a beach ball or a foam ball by spinning it as you throw.

You will need

- A sheet of paper or thin cardboard rolled into a tube (or a potato-chip can with both ends removed)
- A ping-pong ball or small foam ball, and a beach ball or larger foam ball
- Masking tape for a straight launch line on the floor 4 meters long
- A tape measure, a partner and the scorebook

Steps

1. Tape a straight line on the floor 4 meters long. Stand at one end.
2. **No spin:** push the ball out of the end of the tube straight along the line without swinging, like a cannon. Measure how far from the line it lands. Do 5 tries.
3. **Spin:** now swing the tube in an arc so the ball rolls along the inside and leaves spinning. Measure how far from the line it lands. Do 5 tries.
4. Watch which way the ball curves compared with the way it was spinning. Draw it.
5. **Predict:** if you swing the tube the other way, which way will the ball curve? Test 5 tries.
6. Throw the beach ball or large foam ball underhand while giving it strong backspin, then strong topspin. Describe what each spin does to the flight.
7. Find the average distance from the line for each test and make a table.

Tips

- The lighter the ball and the faster it spins, the more it curves.
- Have your partner stand at the far end to mark landing spots.

Check your work

- ☐ I measured 5 launches each with no spin and with spin both ways.
- ☐ I described which way the ball curved compared with its spin.
- ☐ I tested topspin and backspin with a larger ball.

SCOREBOOK

1. Draw a spinning ball from above with arrows for its spin, the air thrown off one side, and the push on the ball.
2. Record your launch table and averages.
3. Write a time line: Magnus explains spinning cannonballs (1852), Cummings's curveball (about 1867), Briggs's wind tunnel tests (1959).

From history. Briggs led the National Bureau of Standards from 1933 to 1945 and had long studied the physics of flight and spinning objects. His curveball study, done after he retired, was published in the *American Journal of Physics* in 1959.

COMMON MISTAKES

- Thinking a curve is only an illusion. It is a real push from the air.
- Mixing up the directions. The ball curves toward the side where its front surface is turning backward, away from the side moving forward into the air.

Make it a game • Curve Reporter. Pretend to be a radio reporter covering Candy Cummings and the first curveball. Give a thirty-second broadcast that explains the Magnus effect in your own words, using the terms spin axis and air pushing sideways. Your parent may ask one question from the audience. Then try one spinning toss and report what the ball did.

BASEBALL AND SOFTBALL

Baseball and softball are full of body mechanics: the throw, the catch, the swing and the pitch. In this unit you will meet Walter Johnson, whose smooth, whip-like delivery made him one of the greatest pitchers ever; Gabby Street, who caught a baseball dropped from the top of the Washington Monument; Babe Ruth, who learned to hit from a teacher at his boyhood school; and Candy Cummings, who said he learned to throw a curveball by tossing clamshells on a beach.

You will learn to throw with your whole body, to catch “soft” by letting your hands give with the ball, to swing level with a foam bat, and to see why a spinning ball curves. Every drill uses soft balls, foam bats and rolled-up socks, with swinging done outdoors and an adult watching.

PREREQUISITES

- Knows the kinetic chain and the order of a good throw (Lesson 1.3)
- Knows that soft hands spread a catch over a longer time (Lesson 5.3)
- Knows the athletic stance (Lesson 1.2)

MASTERY CHECKLIST

- ☐ I can throw with my whole body: step, turn, arm and follow-through.
- ☐ I can catch soft by reaching out and letting my hands give with the ball, and explain why that works.
- ☐ I can swing a foam bat level through the hitting zone and meet the ball out in front.
- ☐ I can explain why a spinning ball curves (the Magnus effect) and show it with a ball and a paper tube.
- ☐ I can follow the safety rules for throwing, catching and swinging.

OPTIONAL BOOKS AND GAMES FOR THIS UNIT

- **MLB Pitch Smart:** Free guidelines from Major League Baseball and USA Baseball on pitch counts and rest days for young pitchers, by age. Parents should read it before any pitching practice. Fits Lessons 6.1 and 6.4.
- **Little League:** Information on youth baseball and softball, including rules and safety. A parent should preview it.

Not required. Every project in this unit works without them. School Launch has no ties to these authors, publishers or companies.

LESSONS IN THIS UNIT

6.1	Throwing with the Whole Body	2 sessions of 45 minutes
6.2	Catching Soft	2 sessions of 45 minutes
6.3	The Level Swing	2 sessions of 45 minutes
6.4	Why Curveballs Curve	2 sessions of 45 minutes

UNIT 6 REVIEW

Answer each question in complete sentences. Show your work for the calculation. You may stand up and show a movement. The review is worth 50 points.

1. **5 pts**
List the five steps of a whole-body throw in order.
2. **5 pts**
Why is a whole-body throw safer for the arm than an arm-only throw?
3. **5 pts**
What would happen if a young pitcher threw many more pitches than the league's pitch count allows, day after day?
4. **5 pts**
What did Gabby Street do on August 21, 1908?

5. (5 pts)

Explain soft hands using the words force and time.

6. (5 pts)

A stiff catch stops a ball in 0.02 seconds and a soft catch in 0.08 seconds. How many times smaller is the average force with the soft catch?

7. (5 pts)

Why does a level swing give a batter a better chance to hit the ball?

8. (5 pts)

What is the sweet spot of a bat, and how can you tell when you hit it?

9. (5 pts)

Who taught young George Ruth to play baseball, and where?

10. (5 pts)

Explain the Magnus effect in your own words and give one example from a sport.

ANSWER KEY

1. Stand sideways and point the glove at the target; step toward the target with the opposite foot; turn the hips and shoulders; bring the arm through with the elbow about shoulder height; follow through across the body.
2. The big muscles of the legs and trunk do most of the work and speed up the arm, so the small muscles of the shoulder and elbow do not have to strain.
3. The arm would get tired and overused, and he would be much more likely to hurt his elbow or shoulder.
4. He caught a baseball dropped from near the top of the Washington Monument, about 555 feet up, on his thirteenth try.
5. Giving with the ball makes the stop take longer, so the force at each moment is smaller; the catch stings less and the ball does not bounce out.
6. $0.08 \div 0.02 = 4$, so the force is 4 times smaller.
7. The bat travels along the path of the ball for longer, so there are more moments when it can meet the ball, instead of one tiny moment with a steep swing.
8. The place on the barrel, a few inches from the end, where the ball jumps off best; the bat barely vibrates and your hands feel little sting.
9. Brother Matthias Boutilier, at St. Mary's Industrial School for Boys in Baltimore.
10. A spinning ball throws air off to one side, so the air pushes the ball the other way and it curves. Examples: a curveball, a bending soccer free kick, topspin in tennis, a golf slice.

PORTFOLIO PIECE: A BACKYARD BASEBALL SKILLS CIRCUIT

Design a four-station baseball and softball skills circuit for your family: a throwing station (point, step and throw at a target), a catching station (soft hands with a beanbag or water balloon), a hitting station (tee work with a foam bat) and a spin station (curve a light ball with a tube or a spinning throw). For each station, make a sign with the instructions, the safety rule and a scorecard. Run the circuit with at least two family members, keep their scores, and write one paragraph on what each person improved.

LOOK FOR	WHAT IT MEANS
Clear stations	Each station has a sign with correct instructions, a safety rule and a way to score.
Physics explained	Each sign includes one sentence of physics: kinetic chain, impulse, level swing or Magnus effect.
Safe running	The circuit was run safely, with swinging outdoors and an adult present.
Records	Scores are recorded for each player, with a short paragraph on improvement.

SOCCER

Soccer, which most of the world calls football, is the most widely played game on earth. Its modern rules were written in London in 1863, and within a few years teams in Scotland had discovered that passing the ball to a teammate could beat even the best dribbler. In this unit you will learn the body mechanics of four soccer skills: the pass with the inside of the foot, the instep kick, dribbling with balance, and why young players do not head the ball.

You will practice outdoors with a soccer ball and indoors with a soft ball or balloon, measuring your accuracy and control. And you will learn a lesson about safety that soccer's leaders learned carefully: some skills should wait until your body is ready.

PREREQUISITES

- Knows the center of gravity and the athletic stance (Lesson 1.2)
- Knows the kinetic chain (Lesson 1.3) and that the angle of a surface aims the ball (Lessons 3.3 and 5.2)
- Knows that soft hands spread a stop over a longer time (Lessons 5.3 and 6.2)

MASTERY CHECKLIST

- ☐ I can tell how the Football Association wrote the first rules in 1863 and how Scottish players made passing the heart of the game.
- ☐ I can pass accurately with the inside of my foot and explain why it is the most accurate kick.
- ☐ I can hit the ball with my instep and explain how a short, hard contact makes it fly fast.
- ☐ I can dribble with small touches, a low center of gravity and my head up.
- ☐ I can explain why U.S. Soccer does not allow heading for players 10 and under, and show the motion safely with a balloon.

OPTIONAL BOOKS AND GAMES FOR THIS UNIT

- **U.S. Soccer: Recognize to Recover:** U.S. Soccer’s player-health program, including the heading guidelines for young players discussed in Lesson 7.4. Written for parents and coaches.

Not required. Every project in this unit works without them. School Launch has no ties to these authors, publishers or companies.

LESSONS IN THIS UNIT

7.1	Passing with the Inside of the Foot	2 sessions of 45 minutes
7.2	The Instep Kick	2 sessions of 45 minutes
7.3	Dribbling and Balance	2 sessions of 45 minutes
7.4	Why Young Players Don’t Head the Ball	2 sessions of 45 minutes

UNIT 7 REVIEW

Answer each question in complete sentences. Show your work for the calculation. You may stand up and show a movement. The review is worth 50 points.

1. **5 pts**
What happened at the Freemasons’ Tavern in London on October 26, 1863?
2. **5 pts**
How did Scotland’s players in the 1870s play differently from England’s, and why did it work?
3. **5 pts**
Why is the inside of the foot the most accurate surface for passing?
4. **5 pts**
What would happen to a pass if the plant foot were placed far behind the ball?
5. **5 pts**
Describe the instep kick.

6. (5 pts)

A kicked ball travels 15 meters in 3 seconds. What is its average speed?

7. (5 pts)

Why does a low center of gravity help a dribbler change direction?

8. (5 pts)

Name three habits of good dribblers.

9. (5 pts)

What are U.S. Soccer's heading guidelines for young players?

10. (5 pts)

Why is a balloon a safe way to practice the heading motion? Use the word momentum.

ANSWER KEY

1. Men from several clubs formed the Football Association, which wrote the first common Laws of the Game.
2. The Scots passed the ball among teammates instead of dribbling alone; the ball moves faster than a runner and a pass can reach an open teammate.
3. It is broad and flat, so small mistakes in where the ball is struck change its direction only a little, unlike the small, round toe.
4. The kicking foot would reach the ball on its way up, so the ball would likely fly into the air instead of rolling along the ground.
5. Approach at a slight angle, plant the foot beside the ball, point the toe down and lock the ankle, knee over the ball, hit through the middle with the laces, follow through and land on the kicking foot.
6. $15 \div 3 = 5$ meters per second.
7. A sideways push off the ground moves the whole body instead of tipping it over, because the center of gravity stays over the feet.
8. Any three: small touches; ball close; knees bent and low; arms out for balance; head up between touches; using different parts of the foot.
9. Players 10 and under do not head the ball at all; players 11 to 13 may head only in practice, with limits.
10. A balloon is very light and slow, so it has very little momentum and makes almost no bump, while you can still learn to use the forehead with eyes open.

PORTFOLIO PIECE: A YOUNG PLAYER’S SOCCER GUIDE

Write and illustrate a four-page guide for a younger child starting soccer. Page 1: the inside-of-the-foot pass. Page 2: the instep kick. Page 3: dribbling with balance. Page 4: “Why we don’t head the ball yet,” explaining the U.S. Soccer guidelines and three ways to control a high ball instead. On each page, include a drawing, three coaching cues and one result from your own projects. Then use your guide to teach a younger child for 15 minutes, and write what went well.

LOOK FOR	WHAT IT MEANS
Accurate technique	Each skill is described correctly with sensible cues (plant foot, locked ankle, knee over ball, small touches).
Safety	The heading page states the guidelines correctly and gives safe alternatives.
Real data	Each page includes a real number or result from the student’s projects.
Teaching	The student taught a real lesson and described it honestly.

7.1 PASSING WITH THE INSIDE OF THE FOOT

OBJECTIVES

- Tell how the Football Association wrote soccer's first rules in 1863 and how passing became the heart of the game.
- Pass a ball with the inside of the foot: plant foot beside the ball, ankle locked, follow through to the target.
- Measure passing accuracy through a gate and improve it with practice.

Warm-up. Set two shoes or water bottles 1 meter apart as a gate. Stand 5 meters away and kick a ball through it five times with your toe, then five times with the inside of your foot. Which kick went through the gate more often?

WATCH

Soccer Passing with Inside of Foot

i play! afterschool • 3:10

<https://www.youtube.com/watch?v=FqnQy9LSowl>

WHEN TO WATCH

After the physics paragraph. Watch where the coach puts his plant foot and how he turns the kicking foot out.

BACKUP VIDEO

#4. How to teach: Passing > Inside foot | Soccer skills in PE (grade K-6)

Prime Coaching Sport • 1:04

https://www.youtube.com/watch?v=yk5Gku_Ojas

A one-minute summary of the key teaching points for the inside-of-the-foot pass.

KEY TERMS

Football Association

The governing body of soccer in England, founded in London in 1863; it wrote the first common rules of the game.

plant foot

The foot you stand on while kicking, placed beside the ball and pointing at the target.

locked ankle

Holding the kicking foot firm, toes up, so it does not flop at contact.

passing game

A way of playing that moves the ball by passes between teammates instead of long dribbles.

CORE IDEAS

The story. In the 1800s, English schools played many different kinds of football, each with its own rules. Some let players carry the ball; some did not. On October 26, 1863, men from several London clubs met at the Freemasons' Tavern and formed the **Football Association**. Ebenezer Cobb Morley, a lawyer who had suggested the meeting, wrote out the first Laws of the Game by hand. In 1872 England played Scotland in Glasgow in the first official international match. England's players liked to dribble the ball long distances alone. Scotland's players, mostly from the Queen's Park club, passed the ball among themselves. The game ended 0–0, but over the next years the Scottish passing style won match after match, and the whole world learned from it.

How they figured it out. The Scots realized that a ball moves faster than any runner. If one player is surrounded, a pass can send the ball to an open teammate in a second. But a pass is only useful if it arrives where it was meant to go, at a speed the teammate can control. Players found that the most accurate surface for passing is the **inside of the foot**, which is broad and flat, like the face of a putter.

The physics. When the foot hits the ball, the ball leaves in the direction the foot's surface is facing and moving, just as with a racket face or a volleyball platform. The inside of the foot gives a large, flat surface, so small mistakes in where you hit the ball do not change its direction much. The toe is a tiny, round point; hit it a little off center and the ball shoots away sideways. A **locked ankle** makes the foot a firm surface, so the ball bounces off cleanly. Placing the **plant foot** beside the ball, pointing at the target, sets your hips and body in line with the pass. Following through toward the target keeps the foot moving in the right direction through the whole contact.

On the field. Coaches teach young players to “plant, lock, swing, follow through.” They practice passing in pairs and through small gates of cones, again and again, with both feet. Good teams pass the ball quickly and accurately, so that every player

is part of the play. A pass is also an act of teamwork: a good passer thinks of the teammate who will receive the ball and sends it at a speed he or she can control.

PICTURE STUDY



Girls' Soccer Team, Blues and Whites, Bain News Service, 1910s · Glass-plate negative · Library of Congress, Prints and Photographs Division
Image: [Wikimedia Commons](#), public domain

The Bain News Service photographed this team of young women at a sports field in the 1910s. Soccer was spreading through American schools and playgrounds, and girls' and women's teams played in the clothing of the time: long skirts or bloomers, sweaters and stockings.

Look closely

- Look at their shoes and clothing. How might long skirts change the way they kicked and passed?
- Count the players. How many would be on a team today?
- Look at the stands behind them. What does that tell you about the game's popularity?

Talk about it

1. Why would passing be an important skill for a team whose players could not run as fast in long clothing?
2. What makes a good teammate on a passing team?
3. If you could ask one of these players a question about her game, what would it be?

Safety first. Pass a real soccer ball outdoors only; indoors, use a soft foam ball or a balloon in a clear space away from windows and furniture. Wear sneakers, not socks or bare feet, for kicking practice. Warm up first.

PROJECT

Through the Gate

You will measure your passing accuracy through gates of different widths and distances, with each foot, and see how practice changes your numbers.

You will need

- A soccer ball (outdoors) or a soft foam ball (indoors)
- Four cones, shoes or water bottles to make gates
- A tape measure, a partner and the scorebook

Steps

1. Make a gate 1 meter wide. Mark passing lines 4 meters and 8 meters from it.
2. **Predict:** out of 10 passes, how many will go through the gate from 4 meters with your stronger foot? With your other foot? From 8 meters?
3. Pass 10 balls through the gate from 4 meters with your stronger foot. Record each one.
4. Pass 10 from 4 meters with your other foot. Record.
5. Pass 10 from 8 meters with each foot. Record.
6. Make the gate narrower (60 cm) and repeat from 4 meters.
7. Pass with a partner for 10 minutes: count how many passes in a row you can make without the ball stopping.
8. Make a table of all your results as fractions and percentages. Which foot needs more practice?

Tips

- Point your plant foot at the gate.
- Keep your ankle locked and your toes up.
- Follow through toward the target.

Check your work

- ☐ I recorded 10 passes for each foot and each distance.
- ☐ I narrowed the gate and tested again.

- ☐ I calculated percentages and named the foot that needs practice.

SCOREBOOK

1. Draw a footprint diagram from above: plant foot beside the ball, kicking foot turned out, arrow to the target.
2. Record your passing table and percentages.
3. Write two sentences about why the Scottish passing game worked.

From history. Morley's handwritten draft of the first Laws of the Game is kept in the archives of the Football Association. Several of the first rules, such as the one allowing a player who caught the ball cleanly to claim a free kick, were later dropped as the game changed.

COMMON MISTAKES

- Placing the plant foot behind the ball, which sends it into the air.
- Letting the ankle flop.
- Passing only with the stronger foot.

Make it a game • Gate Passing Challenge. Make a gate from two shoes. Stand five steps back and pass a ball through it with the inside of your foot. Before each pass, say one cue aloud: plant foot, locked ankle, follow through. Count passes through the gate out of ten, then move one step back and beat your score. End with a fact about 1863.

7.2 THE INSTEP KICK

OBJECTIVES

- Hit a ball with the instep (the laces), toe pointed down, ankle locked, body over the ball.
- Explain how a short, hard contact sends the ball off faster than the foot was moving.
- Measure the speed or distance of instep kicks and compare them with inside-of-the-foot passes.

Warm-up. Outdoors, kick a ball as far as you can five times with your toe and five times with the laces of your shoe, toes pointed down. Mark where each lands. Which went farther? Which went straighter?

WATCH

Instep Kick - Essential Techniques of Soccer

[SimpleSoccerUSA](#) • 7:12

<https://www.youtube.com/watch?v=ToIRV2E9laE>

WHEN TO WATCH

After the physics paragraph. Watch the kicker's toe, ankle and knee at the moment of contact.

BACKUP VIDEO

#6. How to teach: Shooting/striking > Key teaching points | Soccer skills in PE (grade K-6)

[Prime Coaching Sport](#) • 1:44

<https://www.youtube.com/watch?v=7qoHvp0XFX4>

A short summary of the key points of striking the ball, for younger players.

KEY TERMS

instep

The top of the foot, where the laces are; the surface used for powerful kicks and shots.

contact time

How long the foot touches the ball during a kick: about a hundredth of a second.

over the ball

Leaning the knee and body forward over the ball at contact, which keeps a kick low.

approach angle

Running at the ball from slightly to one side, so the leg can swing freely.

CORE IDEAS

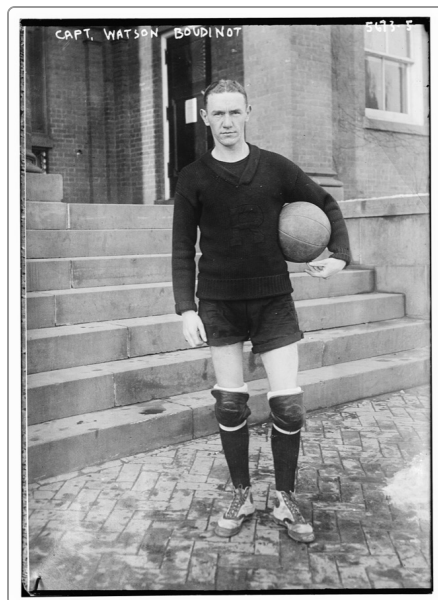
The story. Early soccer balls were made of thick leather sewn around a pig's bladder or rubber bladder and laced up with a leather string. They were heavy, especially when wet, and players wore stiff leather boots with hard toes. Kicking with the toe was common. As balls and boots improved through the 1900s, players learned that the best way to hit a ball hard and straight was with the **instep**, the laces of the boot, with the toe pointed down. Today every shot from distance, every long clearance and every goal kick uses some form of the instep kick.

How they figured it out. Sports scientists filmed kicks at thousands of frames per second. They found that the foot touches the ball for only about one hundredth of a second, and that the ball can leave the foot faster than the foot itself was moving. They also saw that the best kickers swing the leg like a whip: the hip moves first, then the thigh, then the knee straightens with a snap, so the foot is moving at its top speed at the moment of contact. A firm, **locked ankle** mattered, because a loose ankle bends at impact and wastes the kick.

The physics. A kick is a short, hard **impulse**: a large force for a very short time. That is the opposite of catching soft. Here we want the biggest change in the ball's motion, so we want a firm foot and a fast leg. The ball is lighter than the leg and springy, so it squashes against the foot and springs off, leaving faster than the foot. Where you hit the ball matters too. Hit through the middle of the ball with your knee over it and the kick stays low; lean back and hit under the middle and the ball flies high.

On the field. Coaches teach the instep kick in steps: approach from a slight angle, plant the foot beside the ball, point the toe down and lock the ankle, keep the knee over the ball, hit through the middle with the laces, and land on the kicking foot after the follow-through. Young players learn accuracy first. A shot that is on target with medium power is better than a blast that flies over the goal.

PICTURE STUDY



Captain Watson Boudinot, Bain News Service, 1910s · Glass-plate negative · Library of Congress, Prints and Photographs Division

Image: [Wikimedia Commons](#), public domain

The Bain News Service photographed this captain of a soccer team in the 1910s, holding the laced leather ball of the time. Look closely at his heavy boots and the thick ball: kicking them took a strong leg and good technique.

Look closely

- Look at the ball. Can you see the seams or laces? Why would a ball like this get heavy in the rain?
- Look at his boots. Where are the laces? Which part of the boot would he use for a long kick?
- Look at the knee pads. Why might players of his time have worn them?

Talk about it

1. Why would a firm, locked ankle matter even more with a heavy leather ball?
2. How have soccer balls and boots changed since this photograph, and how might that change the way players kick?
3. What do you think a team captain should do besides play well?

Safety first. Kick real balls outdoors only, with no one standing in front of you or near the goal you are shooting at. Wear sneakers or soccer cleats, never bare feet. Warm up first with easy passing and leg swings. If your foot or knee hurts, stop and tell a parent.

PROJECT

Laces versus Inside

You will compare instep kicks with inside-of-the-foot passes for distance and accuracy, and measure how fast your kicks travel.

You will need

- A soccer ball
- Cones or shoes to mark a target and lines
- A tape measure (or count your steps), a stopwatch or phone, a partner and the scorebook

Steps

1. Outdoors, mark a kicking line and a target zone (a goal or a pair of cones 2 meters apart) 15 meters away.
2. **Predict:** which kick will travel faster, an inside-of-the-foot pass or an instep kick? Which will be more accurate?
3. Kick 5 inside-of-the-foot passes as hard as you can at the target. Your partner times how long each takes to reach the target line. Record hits and times.
4. Kick 5 instep kicks, toe down and ankle locked, at the target. Record hits and times.
5. Find each kick's speed: $15 \text{ meters} \div \text{time}$. Find the average for each kind.
6. Now kick 5 instep kicks with your body leaning back, and 5 with your knee over the ball. Record how high each one flies (low, medium, high).
7. Write what you discovered about power, accuracy and height.

Tips

- Start the stopwatch when the foot hits the ball and stop it when the ball crosses the target line.
- Land on your kicking foot after the follow-through.

Check your work

- ☐ I timed 5 passes and 5 instep kicks and calculated speeds.
- ☐ I tested leaning back versus knee over the ball.

- I wrote conclusions about power, accuracy and height.

SCOREBOOK

1. Draw a side view of the instep kick at contact: plant foot, knee over the ball, toe pointed down.
2. Record your timing table and average speeds.
3. Draw a force-over-time graph for a kick (tall and very narrow) next to the one for a soft catch (low and wide).

From history. Leather soccer balls with an inner bladder were used for about a hundred years. Waterproof synthetic balls became common in the 1980s, so that the ball no longer grew heavier as a game went on in the rain.

WORKED EXAMPLES

Example 1. A ball you kicked rolls 20 meters in 4 seconds across a smooth field. What was its average speed?

Show solution

1. $\text{Speed} = \text{distance} \div \text{time}.$
2. $20 \text{ m} \div 4 \text{ s} = 5 \text{ meters per second}.$

Answer: 5 meters per second (the ball started faster and slowed down as it rolled).

COMMON MISTAKES

- Kicking with the toe, which is hard to aim.
- Leaning back, which sends the ball over the goal.
- A floppy ankle at contact.

Make it a game • Laces Or Inside?. Set a target of two cones or shoes. Alternate kicks with the instep and the inside of the foot, guessing before each one which will travel faster and why. A parent keeps a tally of which kick went farther. Tell your parent about contact time to explain the result. First to three wins.

7.3 DRIBBLING AND BALANCE

OBJECTIVES

- Dribble with small, soft touches, keeping the ball close and the head up.
- Explain how a low center of gravity and short steps let a player change direction quickly.
- Time a dribbling course and improve both speed and control.

Warm-up. Run in a straight line, then try to make a sharp turn to the side while standing tall. Now try it again with your knees bent and your body low. Which turn was quicker and steadier? Why?

WATCH

THE BASICS OF DRIBBLING I beginner tutorial

Unisport • 5:33

<https://www.youtube.com/watch?v=naEccnjzLxM>

WHEN TO WATCH

After the physics paragraph. Count how many touches the player takes and notice how low he stays when he turns.

KEY TERMS

dribble

To move with the ball, guiding it with small touches of the feet.

close control

Keeping the ball within a step of your feet so a defender cannot take it.

change of direction

Cutting quickly to one side, which needs a low center of gravity and a strong push off the outside foot.

head up

Looking up between touches to see teammates, defenders and space.

CORE IDEAS

The story. Stanley Matthews, born in 1915 in the English pottery town of Hanley, became one of the greatest dribblers in the history of soccer. He was a slim right winger who could take the ball past defender after defender with tiny touches and sudden changes of direction. He trained hard every day, ate carefully and looked after his body, and he played top-level professional soccer until he was fifty years

old, in 1965. That same year he became the first footballer to be knighted. He was famous for good sportsmanship and is said never to have been sent off in his whole career.

How they figured it out. Coaches who watched great dribblers noticed common habits. They took many small touches instead of a few big kicks, so the ball was always close. They stayed low, with bent knees, and kept their weight on the balls of their feet. They used their arms for balance, and they looked up between touches. When a defender committed to one side, the dribbler shifted his weight and pushed off to the other. Matthews practiced these habits alone for hours as a boy, dribbling around chairs and other obstacles.

The physics. To change direction, you must push sideways against the ground, and the ground pushes you back the other way (Newton's third law). If your **center of gravity** is high, a sideways push tends to tip you over; if it is low and over your feet, the push moves your whole body without toppling it. Small, quick steps keep your feet under you, so you can push in any direction at any moment. Small touches keep the ball moving slowly enough that it stays within reach after each change of direction.

On the field. Young players learn to dribble with every part of the foot: inside, outside, sole and laces. They practice through cones, in small games and in “take the ball” games with a partner. Coaches remind them to keep the ball close in crowded spaces and to push it farther ahead when there is open field in front. Good dribblers also know when to stop dribbling and pass. A team wins with both.

PICTURE STUDY



U.S. Soccer Team at Bonn, Bain News Service, About 1919 · Glass-plate negative · Bonn, Germany;
Library of Congress

Image: [Wikimedia Commons](#), public domain

After the First World War, American soldiers stationed in Germany formed sports teams and played matches against one another. This team, from the army's 42nd Division, posed on a muddy field in the city of Bonn. Soccer was played in all weather, and muddy ground made dribbling and turning even harder.

Look closely

- Look at the ground. How would mud change the way a player dribbles and turns?
- Look at the players in the front row. How are they crouching? Where is their weight?
- Look at their boots and the ball. What would happen to a leather ball on a field like this?

Talk about it

1. On slippery ground, why would a dribbler need to stay even lower and take even smaller touches?
2. Why might soldiers far from home enjoy playing a team game together?
3. What skill from this lesson would help most on a muddy field?

Safety first. Dribble a real ball outdoors or in a garage or basement with plenty of space; indoors in the house, use a soft foam ball. Wear sneakers. Keep cones and obstacles low so no one trips on something hard, and do not dribble on wet, slippery surfaces.

PROJECT

The Dribbling Course

You will set up a dribbling course, time yourself, count lost balls, and work on staying low and keeping the ball close.

You will need

- A soccer ball (outdoors) or a soft foam ball (indoors)
- Six to eight cones, plastic cups or shoes
- A stopwatch or phone, a tape measure, a partner and the scorebook

Steps

1. Set six cones in a straight line, each 1.5 meters apart, with a start and finish line.
2. **Predict** your time to dribble in and out of the cones and back.
3. Dribble the course three times. Your partner times each run and counts how many times the ball got more than a step away from you (a “loose touch”) or knocked a cone.
4. Practice for 10 minutes: dribble around the cones using only the inside of your feet, then only the outside, then both. Stay low and look up between touches.
5. Run the course three more times and record times and loose touches.
6. Make the course harder: set the cones at 1 meter apart. Run it three times.
7. Score each run: time in seconds plus 2 seconds for every loose touch or knocked cone. Compare your best scores before and after practice.

Tips

- Many small touches beat a few big kicks.
- Bend your knees and keep your arms out for balance.
- Look up between touches.

Check your work

- ☐ I timed six runs and counted loose touches.
- ☐ I practiced with different parts of the foot.

- I calculated scores with penalties and compared them.

SCOREBOOK

1. Draw a dribbler from the front, standing tall and then low, and mark the center of gravity in each.
2. Record your course times, loose touches and scores.
3. Draw your course from above with the path you took.

From history. Matthews played his last top-level game for Stoke City just after his fiftieth birthday, in 1965. He spent much of his later life coaching young players in several countries.

COMMON MISTAKES

- Kicking the ball too far ahead.
- Staring at the ball the whole time.
- Standing tall and stiff while turning.

Make it a game • Dribble Commands. Set up four cups in a square. Dribble with soft touches while your parent calls out turn, stop, or head up. Your parent holds up fingers, and you shout the number without looking down. A correct number earns a point. Explain to your parent why a low center of gravity helps you cut quickly.

Scripture. “And every man that striveth for the mastery is temperate in all things.” (1 Corinthians 9:25, KJV)

Matthews kept a careful diet and trained every day so that he could play well for many years. Paul says self-control is the mark of every athlete, and of every Christian.

7.4 WHY YOUNG PLAYERS DON'T HEAD THE BALL

OBJECTIVES

- Explain U.S. Soccer's heading rules for young players and why they were made.
- Show the correct heading motion slowly and safely with a balloon only.
- Measure how hard different balls hit a target, using a pan of flour or a stack of paper cups.

Warm-up. Drop a balloon, a foam ball and a soccer ball onto a pillow from the same height. Which squashes the pillow most? Which would you want to bump with your head? Do not try it; just predict.

WATCH

How to Head a Soccer Ball | Football

SIKANA English • 1:47

https://www.youtube.com/watch?v=sanNB7_HmNQ

WHEN TO WATCH

After the story. Grown players show the heading technique with a real ball. Watch the eyes, forehead and upper body, then practice the motion only with a balloon.

Note: The players in this video are adults. Young players in this course never head a real ball.

KEY TERMS

header

Striking the ball with the forehead to pass, clear or shoot.

forehead

The flat front of the head at the hairline: the only part used for heading, with the eyes open and the neck firm.

guideline

A rule or recommendation made by a sport's governing body to keep players safe.

momentum

How hard something moving is to stop; a heavier, faster ball has more momentum.

CORE IDEAS

The story. For most of soccer's history, children headed the ball just as adults did. Doctors and coaches began to worry that many headers, repeated over years, might not be good for a young person's growing brain and neck. In 2015, U.S. Soccer announced new guidelines for youth soccer, which took effect in 2016: players 10 years old and younger should not head the ball at all, in games or in practice, and players 11 to 13 should head the ball only in practice, with strict limits on how much. Other countries, such as England and Scotland, have since made similar rules.

How they figured it out. Soccer's leaders asked doctors, scientists and coaches to look carefully at what was known and to choose rules that kept young players safe while still teaching good soccer. Young players' heads are large for their bodies, and their neck muscles are not yet strong, so a bump to the head moves the head more than it would in an adult. The safest choice was to wait. Players can learn every other skill now and add heading later, when they are older and stronger, under a coach's care.

The physics. When a ball hits your head, your head must change the ball's motion, and the ball changes your head's motion. A heavier, faster ball has more **momentum**, so the bump is bigger. A soccer ball weighs about 400 grams; a balloon weighs only a few grams and moves slowly, so its bump is tiny. That is why we practice the heading motion with a balloon: you can learn to keep your eyes open, use your forehead and move your whole upper body forward, without a real bump. A strong neck and good technique help older players, because they let the whole body share the force instead of just the head.

On the field. Young players in the United States play without heading, and coaches teach them to control high balls with the chest, thigh and feet instead. When a ball is in the air near a young player, he or she learns to let it bounce and then play it. Older players learn heading slowly, with soft balls first and only a few repetitions. Following a safety rule is not weakness. It is wisdom: caring for the body God gave you so you can enjoy sport for many years. As always, if any bump to the head ever makes you feel dizzy or unwell, stop playing and tell an adult right away.

PICTURE STUDY



English Football Team, Bain News Service, 1910s · Glass-plate negative · Library of Congress, Prints and Photographs Division

Image: [Wikimedia Commons](#), public domain

This photograph of an English football team was taken by the Bain News Service in the 1910s. The leather ball at their feet was much heavier than a modern ball, especially when it soaked up rain, and players headed it often in every game.

Look closely

- Find the ball. How is it different from the ball you use?
- Look at the players' necks and shoulders. How old do you think they are?
- Look at the grandstands. What kind of match do you think this was?

Talk about it

1. Why would heading a wet leather ball be harder on the body than heading a modern ball?
2. Why do you think the heading rules are different for children and adults?
3. What other safety rules in sport protect young players while they grow?

Safety first. Never head a real soccer ball in this course. Practice the heading motion only with a balloon or a very soft, light foam ball tossed gently from close range. Keep your eyes open and use only your forehead. If you ever bump your head and feel dizzy, sick or confused, stop and tell an adult right away.

PROJECT

The Balloon Header and the Flour Test

You will measure how hard different balls land by dropping them into a pan of flour, see why a balloon is safe, and then practice the heading motion with a balloon only.

You will need

- A baking pan filled about 3 cm deep with flour (smoothed flat)
- A balloon, a foam ball, a tennis ball and a soccer ball
- A ruler, a meter stick taped to a wall, and the scorebook
- Balloons for heading practice and a partner

Steps

1. **Predict:** which ball will make the deepest and widest dent in the flour when dropped from 1 meter?
2. Drop each ball from 1 meter into the flour (outdoors or over newspaper). Measure the width of each dent with a ruler. Smooth the flour between drops.
3. Repeat from 2 meters. Did doubling the height change the dents?
4. Make a table of dent widths for each ball and height.
5. **Balloon header practice:** stand in an athletic stance. Your partner tosses a balloon gently from 2 meters. Keep your eyes open, pull your shoulders back, then move your whole upper body forward and meet the balloon with your forehead. Do 10.
6. Aim your balloon headers at your partner's hands. Count how many of 10 reach them.
7. Write a paragraph explaining U.S. Soccer's youth heading rules and why the flour test shows that a balloon is safe.

Tips

- Use your forehead at the hairline, not the top of your head.
- Move your whole upper body, not just your neck.

Check your work

- ☐ I measured the flour dents for four balls at two heights.
- ☐ I practiced the heading motion only with a balloon.
- ☐ I explained the youth heading rules in my own words.

SCOREBOOK

1. Draw the four flour dents side by side, to scale, with their measured widths.
2. Draw the heading motion in three pictures: ready, lean back, forehead meets the balloon.
3. Write three ways a young player can control a high ball without heading it.

From history. England's Football Association issued heading guidelines for young players in 2020, and Scotland followed soon after. The rules differ a little from country to country, but they agree on the main idea: protect young players while they grow.

WORKED EXAMPLES

Example 1. A soccer ball weighs about 400 grams. A balloon weighs about 3 grams. About how many balloons weigh as much as one soccer ball?

Show solution

1. Divide the ball's weight by the balloon's weight: $400 \div 3 \approx 133$.

Answer: About 130 balloons. That is why a balloon is a safe way to practice the heading motion.

COMMON MISTAKES

- Closing the eyes as the balloon arrives.
- Using the top of the head instead of the forehead.
- Thinking a safety rule means a skill is not important. It means the skill should wait.

Make it a game • Header Expert Panel. Pretend to be a sports reporter being interviewed about the U.S. Soccer guidance on heading for young players. Your parent asks three questions: what the rule says, why it was made, and how to head safely. Then demonstrate the heading motion slowly with a balloon only, using the forehead. Parent scores your answers out of three.

Scripture. “For ye are bought with a price: therefore glorify God in your body, and in your spirit, which are God's.” (1 Corinthians 6:20, KJV)

Paul reminds Christians that their bodies belong to God, who bought them at a great price. Your body is a gift to be cared for. Following wise safety rules is one way to honor God with it.

UNIT 7

SOCCER

Soccer, which most of the world calls football, is the most widely played game on earth. Its modern rules were written in London in 1863, and within a few years teams in Scotland had discovered that passing the ball to a teammate could beat even the best dribbler. In this unit you will learn the body mechanics of four soccer skills: the pass with the inside of the foot, the instep kick, dribbling with balance, and why young players do not head the ball.

You will practice outdoors with a soccer ball and indoors with a soft ball or balloon, measuring your accuracy and control. And you will learn a lesson about safety that soccer's leaders learned carefully: some skills should wait until your body is ready.

PREREQUISITES

- Knows the center of gravity and the athletic stance (Lesson 1.2)
- Knows the kinetic chain (Lesson 1.3) and that the angle of a surface aims the ball (Lessons 3.3 and 5.2)
- Knows that soft hands spread a stop over a longer time (Lessons 5.3 and 6.2)

MASTERY CHECKLIST

- ☐ I can tell how the Football Association wrote the first rules in 1863 and how Scottish players made passing the heart of the game.
- ☐ I can pass accurately with the inside of my foot and explain why it is the most accurate kick.
- ☐ I can hit the ball with my instep and explain how a short, hard contact makes it fly fast.
- ☐ I can dribble with small touches, a low center of gravity and my head up.
- ☐ I can explain why U.S. Soccer does not allow heading for players 10 and under, and show the motion safely with a balloon.

OPTIONAL BOOKS AND GAMES FOR THIS UNIT

- **U.S. Soccer: Recognize to Recover:** U.S. Soccer’s player-health program, including the heading guidelines for young players discussed in Lesson 7.4. Written for parents and coaches.

Not required. Every project in this unit works without them. School Launch has no ties to these authors, publishers or companies.

LESSONS IN THIS UNIT

7.1	Passing with the Inside of the Foot	2 sessions of 45 minutes
7.2	The Instep Kick	2 sessions of 45 minutes
7.3	Dribbling and Balance	2 sessions of 45 minutes
7.4	Why Young Players Don’t Head the Ball	2 sessions of 45 minutes

UNIT 7 REVIEW

Answer each question in complete sentences. Show your work for the calculation. You may stand up and show a movement. The review is worth 50 points.

1. **5 pts**
What happened at the Freemasons’ Tavern in London on October 26, 1863?
2. **5 pts**
How did Scotland’s players in the 1870s play differently from England’s, and why did it work?
3. **5 pts**
Why is the inside of the foot the most accurate surface for passing?
4. **5 pts**
What would happen to a pass if the plant foot were placed far behind the ball?
5. **5 pts**
Describe the instep kick.

6. 5 pts

A kicked ball travels 15 meters in 3 seconds. What is its average speed?

7. 5 pts

Why does a low center of gravity help a dribbler change direction?

8. 5 pts

Name three habits of good dribblers.

9. 5 pts

What are U.S. Soccer's heading guidelines for young players?

10. 5 pts

Why is a balloon a safe way to practice the heading motion? Use the word momentum.

ANSWER KEY

1. Men from several clubs formed the Football Association, which wrote the first common Laws of the Game.
2. The Scots passed the ball among teammates instead of dribbling alone; the ball moves faster than a runner and a pass can reach an open teammate.
3. It is broad and flat, so small mistakes in where the ball is struck change its direction only a little, unlike the small, round toe.
4. The kicking foot would reach the ball on its way up, so the ball would likely fly into the air instead of rolling along the ground.
5. Approach at a slight angle, plant the foot beside the ball, point the toe down and lock the ankle, knee over the ball, hit through the middle with the laces, follow through and land on the kicking foot.
6. $15 \div 3 = 5$ meters per second.
7. A sideways push off the ground moves the whole body instead of tipping it over, because the center of gravity stays over the feet.
8. Any three: small touches; ball close; knees bent and low; arms out for balance; head up between touches; using different parts of the foot.
9. Players 10 and under do not head the ball at all; players 11 to 13 may head only in practice, with limits.
10. A balloon is very light and slow, so it has very little momentum and makes almost no bump, while you can still learn to use the forehead with eyes open.

PORTFOLIO PIECE: A YOUNG PLAYER’S SOCCER GUIDE

Write and illustrate a four-page guide for a younger child starting soccer. Page 1: the inside-of-the-foot pass. Page 2: the instep kick. Page 3: dribbling with balance. Page 4: “Why we don’t head the ball yet,” explaining the U.S. Soccer guidelines and three ways to control a high ball instead. On each page, include a drawing, three coaching cues and one result from your own projects. Then use your guide to teach a younger child for 15 minutes, and write what went well.

LOOK FOR	WHAT IT MEANS
Accurate technique	Each skill is described correctly with sensible cues (plant foot, locked ankle, knee over ball, small touches).
Safety	The heading page states the guidelines correctly and gives safe alternatives.
Real data	Each page includes a real number or result from the student’s projects.
Teaching	The student taught a real lesson and described it honestly.

UNIT 8

PRACTICE, SAFETY AND A FIELD DAY

You have learned how the body moves in six sports. In this last unit you will learn how to care for that body so it can keep playing for many years: how to warm up and cool down, why water, rest and sleep are part of training, and how to film a skill in slow motion so you can see what your eyes miss.

Then you will put the whole year together in a family field day. You will plan stations from every unit, run them safely, keep score in your scorebook, and show your guests what you have learned about levers, balance, pendulums, spin and the kinetic chain. “And the streets of the city shall be full of boys and girls playing” (Zechariah 8:5).

PREREQUISITES

- Has completed the projects of Units 1–7 and kept a scorebook
- Can measure time and distance and find an average
- Knows the safety rules for throwing, swinging and kicking

MASTERY CHECKLIST

- ☐ I can lead a dynamic warm-up and a gentle cool-down and explain why each matters.
- ☐ I can explain why water, rest and sleep help athletes, and keep a simple log of my own.
- ☐ I can film a skill in slow motion, study it frame by frame and name one thing to improve.
- ☐ I can plan and run a safe family field day with stations from every unit.
- ☐ I can be a gracious winner and a good loser, and help others enjoy the game.

OPTIONAL BOOKS AND GAMES FOR THIS UNIT

- **KidsHealth: Sleep:** Free. Why children need sleep and how to sleep well, written for children. Fits Lesson 8.2. Ages 8 and up.
- **KidsHealth: Water:** Free. Why the body needs water and when to drink it. Fits Lesson 8.2. Ages 8 and up.

Not required. Every project in this unit works without them. School Launch has no ties to these authors, publishers or companies.

LESSONS IN THIS UNIT

8.1 Warm Up and Cool Down	2 sessions of 45 minutes
8.2 Water, Rest and Sleep	2 sessions of 45 minutes
8.3 Filming a Skill to Check It	2 sessions of 45 minutes
8.4 A Family Field Day	2 sessions of 45 minutes

UNIT 8 REVIEW

Answer each question in complete sentences. Show your work for the calculation.
The review is worth 50 points.

1. **5 pts**
What is the difference between a dynamic warm-up and static stretching, and when should each be done?
2. **5 pts**
Why do warm muscles work better than cold ones?
3. **5 pts**
What did the 2008 study of young soccer players find about the FIFA 11+ warm-up?
4. **5 pts**
Why does an active child need to drink water, especially on a hot day? Use the word sweat.

5. (5 pts)

When do muscles actually grow stronger, and why is sleep part of training?

6. (5 pts)

What would happen to a player who practiced hard every day with little sleep and no rest days?

7. (5 pts)

What question did Muybridge's 1878 photographs answer, and what was the answer?

8. (5 pts)

A phone films at 240 frames per second. How many frames does it take in half a second?

9. (5 pts)

Name four things that make a field day safe and fair.

10. (5 pts)

Describe a gracious winner and a good loser.

ANSWER KEY

1. A dynamic warm-up uses moving exercises to raise the heart rate and loosen joints before sport; static stretches hold still and are best done in the cool-down after sport.
2. Warm muscles stretch more easily and contract faster, and more blood flows to them, like a warm rubber band compared with a cold, stiff one.
3. Players who did the 20-minute warm-up program had about one-third fewer injuries.
4. Muscles make heat; the body cools itself by sweating, and sweat uses water, so lost water must be replaced or the heart works harder and the muscles tire sooner.
5. During recovery after exercise; much repair happens during sleep, and the brain stores practiced movements while we sleep.
6. He would get tired, recover poorly, probably play worse and be more likely to get hurt.
7. Whether all four hooves of a galloping horse leave the ground at once. Yes, they do, but with the legs tucked under the body.
8. $240 \times 0.5 = 120$ frames.
9. Any four: warm-up and cool-down; posted safety rules; adult at swinging stations; soft balls; water and shade; handicaps or age groups; honest scoring; a rotation so everyone plays.
10. A gracious winner thanks and encourages others and does not boast; a good loser congratulates the winner, keeps a good attitude and tries again. Any sensible answer accepted.

PORTFOLIO PIECE: MY BODY MECHANICS HANDBOOK, PART 2, AND THE FIELD DAY REPORT

Finish the handbook you began in Unit 1. Add one page for each sport you studied (bowling, tennis, golf, volleyball, baseball and softball, soccer), each with a drawing of one skill, the physics idea behind it in your own words, and your best before-and-after result from the projects. Then add a field day report: your station map, the signs, the score table and a short reflection on what you learned about teaching, safety and sportsmanship. Present the handbook to your family at the end of the field day.

LOOK FOR	WHAT IT MEANS
Complete handbook	Every sport has a page with a drawing, a physics explanation and a real result.
Accurate physics	The ideas are explained correctly: levers, balance, kinetic chain, pendulum, angle, impulse, spin.
Field day records	The report includes a map, signs, honest scores and a thoughtful reflection.
Safety and sportsmanship	The field day was run safely, and the reflection shows care for guests and good sportsmanship.
Presentation	The student presents the handbook clearly and answers questions about it.

8.1 WARM UP AND COOL DOWN

OBJECTIVES

- Lead a 10-minute dynamic warm-up that moves every major joint.
- Explain why warm muscles work better and why gentle stretching belongs after exercise.
- Measure how a warm-up changes a simple skill, such as a standing long jump or a throw.

Warm-up. Before you do anything else, measure a standing long jump: stand with toes on a line and jump forward with both feet. Mark where your heels land and measure. Now do the warm-up from the video, and jump again. Did it change?

WATCH

Dynamic Warm-Ups for Youth Athletes | Nemours Children's Health

Nemours • 2:42

<https://www.youtube.com/watch?v=KkcmTCvNC4c>

WHEN TO WATCH

At the start of session 1. An athletic trainer from a children's hospital shows a dynamic warm-up for young athletes; do it along with him.

BACKUP VIDEO

Dynamic Warmup for Athletes

Baylor College of Medicine • 4:56

<https://www.youtube.com/watch?v=ZJBprx7oWAM>

A longer dynamic warm-up from a sports-medicine team, for older students.

KEY TERMS

dynamic warm-up

Moving exercises (jogging, skipping, leg swings, arm circles) that gradually raise the heart rate and loosen the joints before sport.

cool-down

Easy movement and gentle stretching after sport that let the heart rate come down slowly.

static stretch

Holding a stretch still for 15 to 30 seconds; best done after exercise.

range of motion

How far a joint can move, such as how high you can swing your leg.

CORE IDEAS

The story. In 1917 and 1918, during the First World War, the U.S. Navy asked Walter Camp, the famous Yale football coach who had helped write the rules of American football, to help keep its officers and sailors fit. Camp designed a short set of exercises that moved the whole body: arm swings, trunk turns, neck rolls and more. After the war he published them as the “Daily Dozen,” and families all over America did them each morning, some along with records on the gramophone. Camp’s idea was simple: a few minutes of the right movements, done every day, prepare the body for work and play.

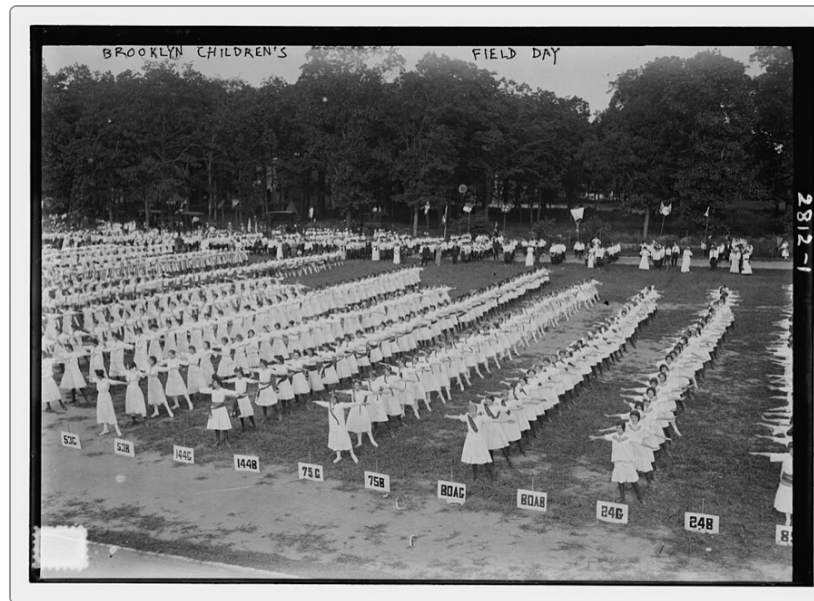
How they figured it out. Coaches had long noticed that athletes who warmed up played better and were hurt less often. Scientists later tested the idea. Muscles that are warm stretch more easily and contract faster, and the heart sends more blood to them. In one large study published in 2008, young soccer players in Norway who did a 20-minute warm-up program called the FIFA 11+ before practice had about one-third fewer injuries than players who did their usual warm-up. Scientists also found that long, still stretches just before sport can make muscles slightly weaker for a short time, so the best warm-up is a moving one, and the long stretches belong at the end.

The physics. Think of a muscle as a rubber band. A cold rubber band is stiff and can snap; a warm one stretches and springs back easily. A **dynamic warm-up** moves each joint through its full **range of motion**, a little farther each time, so that the muscles and tendons are ready to stretch and spring in the kinetic chain. Your heart speeds up gradually, so it is ready for hard work. At the end, a **cool-down** lets the heart slow gradually and the muscles relax, and gentle **static stretches** help keep the joints moving freely.

On the field. Every good team begins practice with a warm-up: jogging, skipping, high knees, leg swings, arm circles, and a few easy versions of the sport’s own skills. It ends with a cool-down: walking, easy jogging and stretching. Players who warm up carefully can practice more, and practicing more is how they improve. Warming

up is also a habit of humility: it admits that our bodies need care. If anything hurts during a warm-up or a game, stop and tell a parent or coach.

PICTURE STUDY



Brooklyn Children's Field Day, Bain News Service, 1910s · Glass-plate negative · Brooklyn, New York; Library of Congress

Image: [Wikimedia Commons](#), public domain

In the early 1900s, the public schools of New York held huge field days in the city's parks. This photograph shows hundreds of Brooklyn children doing exercises together in perfect rows, the kind of drills that were part of every school day then. Numbered signs mark each school's group.

Look closely

- Look at the children's arms. What exercise are they doing?
- Look at the rows. Why would spacing matter when hundreds of children exercise together?
- Find the numbered signs. What do you think they mark?

Talk about it

1. Which joints and muscles would this exercise warm up?
2. Why might exercising together, at the same time, help children keep a good habit?
3. What exercise would you add to make this a complete warm-up for a field day?

Safety first. Warm up on grass or carpet in sneakers, with plenty of space between people. Move gently at first and get gradually bigger and faster. Never bounce hard in a stretch. If anything hurts, stop and tell a parent.

PROJECT

Does a Warm-Up Help?

You will test a skill cold and warm, design your own 10-minute dynamic warm-up and cool-down, and lead your family through it.

You will need

- Masking tape or chalk, a tape measure and a stopwatch
- A soft ball for throws
- Paper for a warm-up card, and the scorebook

Steps

1. **Cold test:** at the start of a session, before moving around, do three standing long jumps and three soft-ball throws for distance. Record the best of each.
2. **Warm-up:** do 10 minutes of dynamic warm-up: 2 minutes of easy jogging, then high knees, butt kicks, skips, side shuffles, leg swings (front and side), arm circles, trunk turns and a few easy throws.
3. **Warm test:** repeat three long jumps and three throws. Record the best of each.
4. Compare cold and warm results. (One test is not proof; repeat on two more days if you can.)
5. Design your own warm-up card with eight moving exercises in a good order, from gentle to stronger. Draw a stick figure for each.
6. Design a 5-minute cool-down with walking and four gentle stretches held for 20 seconds each.
7. Lead your family through your warm-up and cool-down. Ask them what felt good and what to change.

Tips

- Start gently. The warm-up should make you warm, not tired.
- Move each joint a little farther each time.

Check your work

- ☐ I tested two skills cold and warm and recorded the results.

- ☐ I made a warm-up card and a cool-down plan.
- ☐ I led my family through both.

SCOREBOOK

1. Draw your warm-up card with eight exercises and the body part each one prepares.
2. Record your cold and warm test results in a table.
3. Write which joints of the kinetic chain your warm-up prepares for a throw.

From history. Walter Camp's "Daily Dozen" exercises were so popular that they were sold as a set of records with music, so families could exercise together at home. Camp lived from 1859 to 1925 and is often called the father of American football.

COMMON MISTAKES

- Skipping the warm-up to save time.
- Holding long, still stretches before sport instead of moving.
- Making the warm-up so hard that you are tired before the game.

Make it a game • Joint Warm-Up Leader. Lead your parent through a warm-up in head-to-toe order, calling out each major joint as you move it: neck, shoulders, hips, knees, ankles. Your parent must say the movement name back to you. Stretch gently only at the end. Afterward, explain in one sentence why a warm-up comes before and a static stretch comes after.

8.2 WATER, REST AND SLEEP

OBJECTIVES

- Explain why the body needs water during exercise and how to drink wisely.
- Explain why muscles grow stronger during rest, and why sleep is part of training.
- Keep a one-week log of sleep, water and practice, and look for patterns.

Warm-up. Weigh yourself on a bathroom scale before and after 20 minutes of active play on a warm day (with a parent's help, wearing the same clothes). Did your weight change? Where do you think the difference went?

WATCH

Why Do We Need Sleep?

SciShow Kids · 3:33

https://www.youtube.com/watch?v=_aAmaCeq9v4

WHEN TO WATCH

After the physics paragraph. Listen for what your body and brain do while you sleep.

KEY TERMS

hydration

Having enough water in the body. Water carries heat away as sweat, cushions joints and helps muscles work.

recovery

The time after exercise when the body repairs and strengthens muscles.

sleep

The body's nightly rest, when the brain sorts what it has learned and the body builds and repairs.

Sabbath

The day of rest God gave His people, one day in seven.

CORE IDEAS

The story. At the 1924 Olympic Games in Paris, the Scottish runner Eric Liddell learned that the heats of his best event, the 100 meters, would be run on a Sunday. Liddell was a Christian who kept Sunday as the Lord's Day, a day of worship and rest,

and he would not run. Instead he trained for the 400 meters, a longer and harder event, and won the gold medal in a world-record time. Liddell later served as a missionary teacher in China. His story is remembered not only for courage but for his trust that God's pattern of work and rest is good.

How they figured it out. Scientists have learned that muscles do not grow stronger during exercise; they grow stronger during **recovery** afterward, when the body repairs the tiny strains of hard work. They also found that **sleep** is when much of that repair happens, and when the brain stores new movements it has practiced. In one study at Stanford University, published in 2011, basketball players who slept about ten hours a night for several weeks ran faster sprints and shot about nine percent better from the free-throw line and the three-point line. Doctors recommend about 9 to 12 hours of sleep a night for children ages 6 to 12, and 8 to 10 hours for teenagers.

The physics. Your muscles turn food energy into motion, and much of that energy becomes heat. Your body gets rid of the heat by sweating: as sweat evaporates from your skin, it carries heat away. That cooling uses water, so on a hot day an active child can lose a good deal of water in an hour. Lose too much and your heart works harder, your muscles tire sooner and your thinking slows down. Drinking water before, during and after exercise refills what you lose. The weight you lost in the warm-up test was mostly water.

On the field. Good athletes drink water regularly during practice, rest when they are tired, and protect their sleep. Coaches plan easy days after hard ones. Many Christian athletes also keep a weekly day of rest and worship, as Liddell did. On hot days, practice in the cooler hours, wear a hat and light clothing, take breaks in the shade and drink often. If you feel dizzy, sick or very hot, stop, rest in the shade, drink water and tell an adult right away.

PICTURE STUDY



Noon: Rest from Work (after Millet), Vincent van Gogh, 1890 · Oil on canvas · Musée d'Orsay, Paris

Image: [Wikimedia Commons](#), public domain

Van Gogh admired the French painter Jean-François Millet, who painted the hard work of farm families. Van Gogh painted this copy of one of Millet's drawings, in his own bright colors, near the end of his life. Two harvest workers rest in the shade at midday, the hottest part of the day.

Look closely

- Find the tools the workers have put aside. What work have they been doing?
- Look at where they are lying. Why would they choose the shade of the haystack?
- Look at the colors of the field and sky. What time of day and what season is it?

Talk about it

1. Why is rest in the middle of hard work wise, not lazy?
2. What would a harvest worker need besides rest on a hot day?
3. How is an athlete's rest like this farmer's rest?

Safety first. Drink water before, during and after active play, and more on hot days. Play in the shade or in the cooler hours when it is hot. If you feel dizzy, sick or very hot, stop, rest in the shade, drink water and tell an adult right away. Ask a parent or doctor about any health question.

PROJECT

My Training Log

You will keep a one-week log of your sleep, water and activity, and test one skill each day to look for patterns.

You will need

- A water bottle with marks for how much you drink (or a measuring cup)
- A notebook page set up as a log, and the scorebook
- A simple daily skill test, such as 10 balloon passes in a row or 10 tosses at a bucket

Steps

1. Make a log with seven rows (days) and these columns: bedtime, wake time, hours of sleep, cups of water, minutes of active play, skill-test score, how I felt (1–5).
2. **Predict:** will your best skill scores come on days after more sleep?
3. Each morning, record your sleep. Each evening, record your water and activity.
4. Each afternoon, do the same short skill test and record your score.
5. Choose one day of the week as a rest day with no hard practice.
6. At the end of the week, make a graph with hours of sleep on one axis and skill score on the other, one dot per day.
7. Write what patterns you see. Remember that one week is a small sample, so be careful about conclusions.

Tips

- Be honest in your log; it is for you.
- A regular bedtime helps more than catching up on sleep later.

Check your work

- ☐ I logged seven days of sleep, water, activity and a skill test.
- ☐ I made a graph of sleep and skill score.
- ☐ I wrote what I noticed and why I should be careful about it.

SCOREBOOK

1. Copy your one-week log neatly.
2. Draw your sleep-and-skill graph and circle any pattern.
3. Write a short plan for your own healthy week: bedtime, water, practice days and a day of rest.

From history. Liddell's choice was made months before the Paris Games, when the schedule was published, so he had time to train for the 400 meters. He was born in China to missionary parents and returned there to teach after his running career.

COMMON MISTAKES

- Waiting until you are very thirsty to drink.
- Thinking more practice is always better than rest.
- Staying up late before a big game.

Make it a game • Training Log Trivia. Fill in five lines of an imaginary training log from memory: water, sleep, rest day, hard day, easy day. Your parent asks why each matters, and you answer in one sentence. Add one bonus point for explaining where the Sabbath fits in a week of training. Try to answer all five in sixty seconds.

Scripture. “for so he giveth his beloved sleep.” (Psalm 127:2, KJV)

Sleep is a gift from God, not wasted time. Resting well is part of serving Him with a healthy body.

8.3 FILMING A SKILL TO CHECK IT

OBJECTIVES

- Tell how Eadweard Muybridge photographed a galloping horse in 1878 and what it showed.
- Film a skill in slow motion and study it frame by frame.
- Compare your movement with a good model and choose one thing to improve, then film again.

Warm-up. Watch a family member walk across the room and try to say exactly what each foot is doing at every moment. Is there ever a moment when both feet are on the ground? When neither is? It is hard to see at normal speed. How could you find out?

WATCH

What is Motion - Eadweard Muybridge

[Cantor Arts Center](#) · 1:32

<https://www.youtube.com/watch?v=6XGEq37Dnso>

WHEN TO WATCH

After the story. A museum at Stanford University shows Muybridge's cameras and photographs.

KEY TERMS

frame

One still picture in a series. A video is many frames shown quickly one after another.

slow motion

Video taken at many frames per second and played back more slowly, so fast movements can be seen.

frames per second

How many pictures a camera takes each second. Normal video is about 30; slow motion is 120 or 240.

checkpoint

A key moment in a skill to look at, such as the plant foot at contact or the finish of a swing.

CORE IDEAS

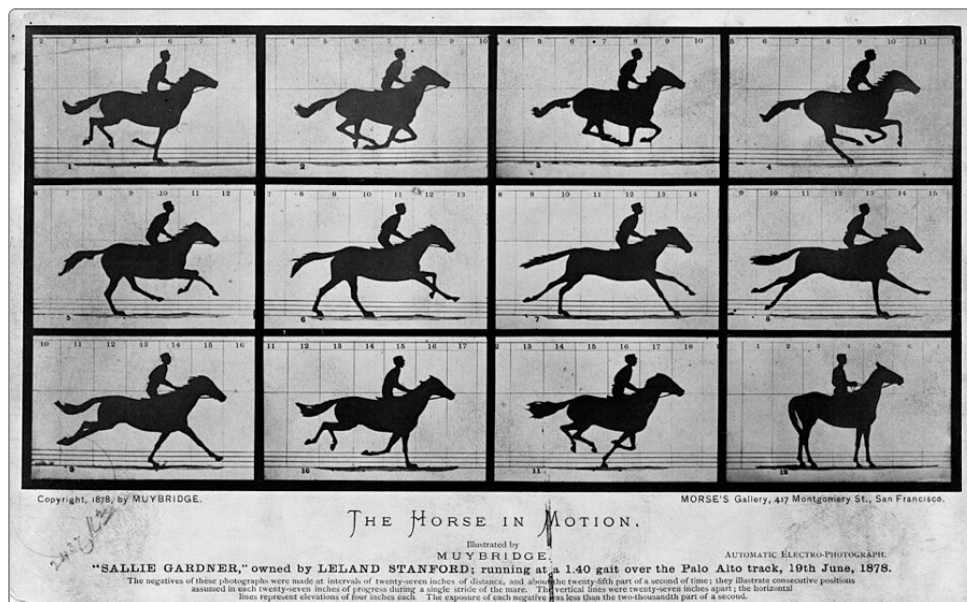
The story. In the 1870s, people argued about a simple question: when a horse gallops, is there a moment when all four of its hooves are off the ground at once? The eye could not tell. Leland Stanford, a former governor of California who raised horses, hired the photographer Eadweard Muybridge to find out. On June 19, 1878, at Stanford's farm in Palo Alto, Muybridge set up a row of twelve cameras beside the track. As the mare Sallie Gardner galloped past, she broke a line of threads that tripped each camera in turn. The pictures showed the answer: yes, all four hooves were off the ground, but tucked up under the horse, not stretched out front and back as painters had always drawn them.

How they figured it out. Muybridge's idea was to cut a fast motion into many still frames taken very close together in time. Each camera's shutter was open for only a tiny fraction of a second, so each picture was sharp. Lined up in order, the frames showed every stage of the gallop. Muybridge went on to photograph thousands of motions of animals and people, and his work led to the invention of motion pictures. Coaches and scientists have used the same idea ever since: film a skill, slow it down, and look at each frame.

The physics. A fast movement happens in a very short time. A tennis serve's contact lasts only a few thousandths of a second; a kick touches the ball for about a hundredth of a second. Normal video takes about 30 **frames per second**, so it may miss the most important moment. Many phones can film slow motion at 120 or 240 frames per second, which shows 4 or 8 times as many moments. By stepping through the frames, you can see the order of the kinetic chain, the angle of a racket face, the position of a plant foot or the balance of a finish.

On the field. Coaches film practices and games, and players study the video to see what they cannot feel. A good way to study your own skill is to choose two or three **checkpoints** before you film (for example, "plant foot beside the ball," "knee over the ball," "follow-through to target"), then check each one frame by frame. Change only one thing at a time, film again and compare. If you do not have a camera, a partner who watches closely and describes what he or she sees works too.

PICTURE STUDY



The Horse in Motion, Eadweard Muybridge, 1878 · Photographs printed on a card · Palo Alto, California;
Library of Congress

Image: [Wikimedia Commons](#), public domain

This card shows the twelve photographs Muybridge took of the mare Sallie Gardner galloping on June 19, 1878. They were printed and sold so that people everywhere could see the answer to the old question. The numbered lines behind the horse helped measure how far it moved between frames.

Look closely

- Find the frames where all four hooves are off the ground. Where are the legs?
- Follow one leg through all twelve frames. When does it touch the ground?
- Look at the rider. Does he move as much as the horse?
- Find the lines and numbers in the background. How could they help measure the horse's speed?

Talk about it

1. Why could no one answer the question before these photographs?
2. Which skill of your own would you most like to see broken into twelve frames?
3. Muybridge needed twelve cameras; you can use one phone. What could you discover with it?

Safety first. When filming, the camera person stands well to the side of the action, never in front of a thrower, kicker or swinger. Film swinging skills outdoors only. Ask permission before filming anyone, and keep family videos private.

PROJECT

My Before-and-After Motion Study

You will choose one skill from this year, film it in slow motion, study three checkpoints frame by frame, practice one fix and film it again.

You will need

- A phone or tablet that can film slow motion (or a partner who watches closely)
- The equipment for your chosen skill (a soft ball, balloon, foam bat, soccer ball or putter)
- A printed or drawn checkpoint sheet, and the scorebook

Steps

1. Choose one skill: a throw, a tennis forehand with a balloon, a putt, a forearm pass, a foam-bat swing or an instep kick.
2. Write three checkpoints for that skill from this year's lessons.
3. Film the skill five times from the side in slow motion, with the camera at about waist height and held still.
4. Step through the best video frame by frame. For each checkpoint, write yes or not yet. If you can, pause on the key frame and sketch it.
5. Choose the one checkpoint that most needs work. Practice it for 10 minutes on three different days.
6. Film the skill five more times in the same way.
7. Compare your before and after videos. Make a chart of the checkpoints, before and after.
8. Show your best before-and-after frames to your family and explain what you changed.

Tips

- Film from the same spot and angle both times so the comparison is fair.
- Good light helps slow-motion video look sharp.

Check your work

- ☐ I filmed my skill before and after practice from the same angle.
- ☐ I checked three checkpoints frame by frame.
- ☐ I practiced one fix and showed the change.

SCOREBOOK

1. Draw six frames of your skill from your video, like Muybridge's card.
2. Record your checkpoint chart, before and after.
3. Write what slow motion showed you that you could not see at full speed.

From history. Muybridge later invented the zoopraxiscope, a machine that projected his photographs in quick order so they appeared to move: an early ancestor of movies. His original cameras and many of his photographs are kept at Stanford University.

WORKED EXAMPLES

Example 1. A phone films slow motion at 240 frames per second. A kick's contact lasts about 0.01 seconds. About how many frames will show the foot touching the ball? At normal video (30 frames per second)?

Show solution

1. Slow motion: $240 \times 0.01 = 2.4$, so about 2 frames.
2. Normal video: $30 \times 0.01 = 0.3$, so most of the time no frame at all catches the contact.

Answer: About 2 frames in slow motion, and usually none at normal speed. That is why slow motion helps.

COMMON MISTAKES

- Filming from the front or at an angle, so the important movements are hidden.
- Trying to fix everything at once.
- Moving the camera between the before and after videos.

Make it a game • Freeze-Frame Muybridge. Act out a skill in slow motion while your parent takes four pretend photographs by saying click and pointing at the pose. Draw those four frames from memory on paper. Then explain what Eadweard Muybridge showed about the galloping horse in 1878. Compare your frames with the skill's checkpoints, and name one thing to fix.

8.4 A FAMILY FIELD DAY

OBJECTIVES

- Plan a field day with one safe station from each sport unit.
- Run the field day, keep fair scores and help every guest take part.
- Show sportsmanship as a gracious winner and a good loser.

Warm-up. Make a list of every project you did this year. Put a star next to the three that were the most fun and a check next to the three that would be easiest to set up for guests. Which would make the best field-day stations?

WATCH

How to Run a Three-legged Race

Howcast • 1:00

<https://www.youtube.com/watch?v=VtScuwFwRRs>

WHEN TO WATCH

While you plan. A one-minute guide to the three-legged race, a classic field-day event to add to your stations.

BACKUP VIDEO

How To Play Sack Race?

Mr.Animate • 1:45

https://www.youtube.com/watch?v=IA_sjc9dfKs

A short animated guide to the sack race and its relay version.

KEY TERMS

station

One place in a field day where guests try one skill and record a score.

rotation

Moving groups from station to station on a schedule, so everyone tries everything.

sportsmanship

Playing fairly and kindly: following the rules, encouraging others, and winning and losing with grace.

handicap

A fair adjustment (a shorter distance or an extra try) that lets players of different ages compete together.

CORE IDEAS

The story. In the early 1900s, the public schools of New York and other cities held great field days in their parks. Thousands of children took part in exercises, races and games: the 50-yard dash, the wheelbarrow race, the ring toss and more, while families watched from the stands. School field days spread across America and are still held every spring. They were meant to give every child, not just the best athletes, a day of healthy play.

How they figured it out. The teachers who planned those field days had to solve real problems: how to keep thousands of children safe, how to keep everyone busy, and how to make the contests fair for children of different ages. Their answers still work. Divide the day into **stations**. Move groups on a **rotation** schedule. Use age groups or **handicaps** so that younger children have a fair chance. Give clear rules and keep honest scores. And make sure every child gets to play.

The physics. A field day is a review of everything you learned this year. The bottle-bowling station uses the pendulum swing. The balloon-tennis station uses the racket face and the kinetic chain. The putting station uses the pendulum putt and green speed. The volleyball station uses the angle of the platform. The throwing station uses the whole-body throw. The soccer station uses the locked ankle and the inside of the foot. At each station, your guests will be using levers, balance, momentum and spin, whether they know it or not, and you can explain it to them.

On the field. A good host thinks about the guests: the youngest child, the grandparent and the shy cousin. Set up stations that everyone can try, with easier versions for younger players. Keep safety rules posted at each station. Encourage every guest by name. Keep scores honestly, and celebrate effort and improvement as well as the best score. Finish with a cool-down, a snack, water and a word of thanks. As Paul wrote, “every man that striveth for the mastery is temperate in all things” (1 Corinthians 9:25); good sport is self-controlled, kind and joyful.

PICTURE STUDY



Wheelbarrow Race, Brooklyn Field Day, Bain News Service, 1910s · Glass-plate negative · Brooklyn, New York; Library of Congress

Image: [Wikimedia Commons](#), public domain

This photograph from a Brooklyn school field day in the 1910s shows a wheelbarrow race. One partner walks on his hands while the other holds his legs and runs behind. It takes teamwork, strength, timing and balance.

Look closely

- Look at the boys walking on their hands. Where is their center of gravity? Where is their base of support?
- Look at the partners holding the legs. Are they going fast or carefully?
- Which pair do you think is winning? Why?

Talk about it

1. What makes the wheelbarrow race a good teamwork event?
2. What safety rules would you give before a wheelbarrow race?
3. How could you make a field day fair and fun for children of different ages?

Safety first. Every station follows the safety rules from its unit: soft balls and balloons, swinging only outdoors with a clear circle, no heading of real soccer balls, and an adult at any station with a bat, club or broomstick. Start with a warm-up, keep water and shade available, and end with a cool-down. Anyone who is hurt stops and tells an adult.

PROJECT

Run the Family Field Day

You will plan, set up and run a family field day with at least six stations, one from each sport unit, plus a warm-up, a race and a cool-down. You will keep every score in your scorebook.

You will need

- Equipment from your projects: bottles and a soft ball, balloons and paper-plate rackets, a putter and cups, a beach ball and a string net, a foam bat and tee, a soccer ball and cones
- Signs for each station (rules, safety rule, how to score)
- Score cards for every guest, pencils, a stopwatch and a tape measure
- Water, snacks and a shady place to rest
- Ribbons or homemade certificates (optional)

Steps

1. **Plan** the stations: (1) bottle bowling, (2) balloon tennis rally, (3) household or yard putting, (4) beach-ball volleyball passing, (5) throwing at a target and tee hitting, (6) soccer passing through a gate. Add a short race, such as a three-legged race or a sack race.
2. Write a sign for each station with the rules, the safety rule, the scoring and one sentence of the physics behind it.
3. Make score cards and a rotation schedule (about 8 minutes per station).
4. Invite your guests and decide on fair handicaps for younger players.
5. On the day, lead the warm-up from Lesson 8.1.
6. Run the rotation. At each station, explain the skill and the physics briefly and keep scores honestly.
7. Finish with the race, a cool-down and an awards time that celebrates effort and improvement as well as top scores.
8. Afterward, total the scores in your scorebook and write what went well and what you would change next time.

Tips

- Ask a parent or older sibling to supervise the swinging station.
- Keep the stations simple so guests spend their time playing, not waiting.

Check your work

- ☐ I planned and ran at least six stations from different units.
- ☐ Every station had a posted safety rule and honest scoring.
- ☐ I wrote a reflection on the day.

SCOREBOOK

1. Draw a map of your field day with every station, the rotation path, the water station and the shade.
2. Copy the final scores in a table for each guest and each station.
3. Write about a moment of good sportsmanship you saw, by a guest or by yourself.

From history. The children in the Brooklyn field day photographs were taking part in the Public Schools Athletic League, founded in New York in 1903 to give city children healthy games and sport. It still runs school sports in New York City today.

COMMON MISTAKES

- Planning too many stations, so the day runs long.
- Forgetting water and shade.
- Making the stations too hard for younger guests.

Make it a game • Field Day Ticket Race. Make a ticket card for each sport unit: bowling, tennis, golf, volleyball, baseball, soccer. Draw one at a time and name one safe skill and its key cue from memory. If you can show the skill, you keep the ticket. Collect all six within five minutes. Parents add one handicap rule to keep the game fair.

Scripture. “And the streets of the city shall be full of boys and girls playing in the streets thereof.” (Zechariah 8:5, KJV)

The prophet pictures children playing freely as a sign of God’s blessing on a peaceful city. A family field day is a small picture of that joy.

PRACTICE, SAFETY AND A FIELD DAY

You have learned how the body moves in six sports. In this last unit you will learn how to care for that body so it can keep playing for many years: how to warm up and cool down, why water, rest and sleep are part of training, and how to film a skill in slow motion so you can see what your eyes miss.

Then you will put the whole year together in a family field day. You will plan stations from every unit, run them safely, keep score in your scorebook, and show your guests what you have learned about levers, balance, pendulums, spin and the kinetic chain. “And the streets of the city shall be full of boys and girls playing” (Zechariah 8:5).

PREREQUISITES

- Has completed the projects of Units 1–7 and kept a scorebook
- Can measure time and distance and find an average
- Knows the safety rules for throwing, swinging and kicking

MASTERY CHECKLIST

- ☐ I can lead a dynamic warm-up and a gentle cool-down and explain why each matters.
- ☐ I can explain why water, rest and sleep help athletes, and keep a simple log of my own.
- ☐ I can film a skill in slow motion, study it frame by frame and name one thing to improve.
- ☐ I can plan and run a safe family field day with stations from every unit.
- ☐ I can be a gracious winner and a good loser, and help others enjoy the game.

OPTIONAL BOOKS AND GAMES FOR THIS UNIT

- **KidsHealth: Sleep:** Free. Why children need sleep and how to sleep well, written for children. Fits Lesson 8.2. Ages 8 and up.
- **KidsHealth: Water:** Free. Why the body needs water and when to drink it. Fits Lesson 8.2. Ages 8 and up.

Not required. Every project in this unit works without them. School Launch has no ties to these authors, publishers or companies.

LESSONS IN THIS UNIT

8.1 Warm Up and Cool Down	2 sessions of 45 minutes
8.2 Water, Rest and Sleep	2 sessions of 45 minutes
8.3 Filming a Skill to Check It	2 sessions of 45 minutes
8.4 A Family Field Day	2 sessions of 45 minutes

UNIT 8 REVIEW

Answer each question in complete sentences. Show your work for the calculation.
The review is worth 50 points.

1. **5 pts**
What is the difference between a dynamic warm-up and static stretching, and when should each be done?
2. **5 pts**
Why do warm muscles work better than cold ones?
3. **5 pts**
What did the 2008 study of young soccer players find about the FIFA 11+ warm-up?
4. **5 pts**
Why does an active child need to drink water, especially on a hot day? Use the word sweat.

5. (5 pts)

When do muscles actually grow stronger, and why is sleep part of training?

6. (5 pts)

What would happen to a player who practiced hard every day with little sleep and no rest days?

7. (5 pts)

What question did Muybridge's 1878 photographs answer, and what was the answer?

8. (5 pts)

A phone films at 240 frames per second. How many frames does it take in half a second?

9. (5 pts)

Name four things that make a field day safe and fair.

10. (5 pts)

Describe a gracious winner and a good loser.

ANSWER KEY

1. A dynamic warm-up uses moving exercises to raise the heart rate and loosen joints before sport; static stretches hold still and are best done in the cool-down after sport.
2. Warm muscles stretch more easily and contract faster, and more blood flows to them, like a warm rubber band compared with a cold, stiff one.
3. Players who did the 20-minute warm-up program had about one-third fewer injuries.
4. Muscles make heat; the body cools itself by sweating, and sweat uses water, so lost water must be replaced or the heart works harder and the muscles tire sooner.
5. During recovery after exercise; much repair happens during sleep, and the brain stores practiced movements while we sleep.
6. He would get tired, recover poorly, probably play worse and be more likely to get hurt.
7. Whether all four hooves of a galloping horse leave the ground at once. Yes, they do, but with the legs tucked under the body.
8. $240 \times 0.5 = 120$ frames.
9. Any four: warm-up and cool-down; posted safety rules; adult at swinging stations; soft balls; water and shade; handicaps or age groups; honest scoring; a rotation so everyone plays.
10. A gracious winner thanks and encourages others and does not boast; a good loser congratulates the winner, keeps a good attitude and tries again. Any sensible answer accepted.

PORTFOLIO PIECE: MY BODY MECHANICS HANDBOOK, PART 2, AND THE FIELD DAY REPORT

Finish the handbook you began in Unit 1. Add one page for each sport you studied (bowling, tennis, golf, volleyball, baseball and softball, soccer), each with a drawing of one skill, the physics idea behind it in your own words, and your best before-and-after result from the projects. Then add a field day report: your station map, the signs, the score table and a short reflection on what you learned about teaching, safety and sportsmanship. Present the handbook to your family at the end of the field day.

LOOK FOR	WHAT IT MEANS
Complete handbook	Every sport has a page with a drawing, a physics explanation and a real result.
Accurate physics	The ideas are explained correctly: levers, balance, kinetic chain, pendulum, angle, impulse, spin.
Field day records	The report includes a map, signs, honest scores and a thoughtful reflection.
Safety and sportsmanship	The field day was run safely, and the reflection shows care for guests and good sportsmanship.
Presentation	The student presents the handbook clearly and answers questions about it.