# Force And Motion

Physical Science | Lesson Guide

5th Grade

## Photo Description

This image shows a student in mid-air, jumping over an orange cone during an outdoor athletic activity. The student's body is in a dynamic jumping position, demonstrating the motion created when muscles push against the ground with force. Other students and spectators can be seen in the background, indicating this is part of an organized physical activity or competition.

## Scientific Phenomena

Anchoring Phenomenon: How does a person jump into the air and land safely?

This photograph captures the moment when a student applies a large downward force through their leg muscles to push against the ground. According to Newton's Third Law of Motion, when the student pushes down on Earth with force, Earth pushes back up on the student with an equal force. This upward force is greater than the pull of gravity for a brief moment, causing the student to accelerate upward and become airborne. The student's mass, muscle strength, and the speed of the push all affect how high they jump and how long they stay in the air before gravity pulls them back down.

## Core Science Concepts

* Force and Motion: A force is a push or pull that causes an object to start moving, stop moving, or change direction. The student's leg muscles apply a large force downward, which creates the jumping motion.

* Newton's Third Law of Motion: For every action, there is an equal and opposite reaction. The student pushes down on the ground; the ground pushes up on the student with equal force.

* Gravity: This invisible force pulls all objects toward Earth. As the student rises into the air, gravity continuously pulls them back downward, ending the jump.

* Acceleration: The student's velocity (speed and direction) changes rapidly during takeoff due to the net force acting on them. This change in velocity is called acceleration.

> **Pedagogical Tip:**
>
> Students often struggle to visualize forces that aren't visible. Use slow-motion video replays of jumps to help fifth graders "see" the acceleration phase. Have them observe how the student's body position changes from crouched to extended—this visible change helps them understand the invisible forces at work.

> **UDL Suggestions:**
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> Provide multiple means of engagement by offering choice in how students demonstrate understanding: kinesthetic learners can perform and measure their own jumps, visual learners can create force diagrams or annotated photos, and verbal learners can explain jumping mechanics to peers. Use a force scale or pressure mat (if available) to give quantitative feedback that appeals to different learning preferences.

## Zoom In / Zoom Out

Zoom In: Muscle Fibers and Cells
When the student crouches to jump, millions of muscle cells in their legs are contracting all at once. Inside each muscle cell are tiny structures called mitochondria that use energy from food to power the contraction. The muscle fibers shorten and pull on the bones, creating the force that pushes against the ground. At the microscopic level, protein molecules are sliding past each other to create this movement—a process that happens in fractions of a second!

Zoom Out: Energy Systems and Athletics
A single jump is part of a larger system of human movement and athletic performance. When we zoom out, we see how jumping connects to fitness, nutrition, training, and even social systems like organized sports. Students who jump regularly develop stronger muscles and better coordination. At the community level, athletic events like this one bring people together and teach teamwork. At the planetary level, humans use jumping and running movements across all cultures and environments—from ancient hunting practices to modern Olympic competitions.

## Discussion Questions

1. What forces are acting on the student while they are in the air? (Bloom's: Analyze | DOK: 2)
2. Why does the student come back down to the ground after jumping? (Bloom's: Understand | DOK: 1)
3. How would the student's jump be different on the Moon, where gravity is weaker than on Earth? (Bloom's: Evaluate | DOK: 3)
4. What changes would the student need to make to jump higher—more force, less force, or the same amount of force? (Bloom's: Apply | DOK: 2)

## Potential Student Misconceptions

Misconception 1: "Gravity only pulls down when you're falling, not when you're in the air."
Clarification: Gravity is always pulling downward on the student—even while they're in mid-air jumping. During the jump, the student's upward motion is stronger than gravity's pull, so they rise. But gravity is always working, pulling them back down until they land. Gravity doesn't turn on and off; it's always there!

Misconception 2: "The student needs to push harder on the ground to jump higher, but the ground also pushes back harder."
Clarification: This is partially correct, but it's important to understand that the ground always pushes back with exactly the same force that the student pushes down (Newton's Third Law). To jump higher, the student doesn't need the ground to push back more—they need to push down with more force in the first place. The ground's response is always equal, but a stronger initial push creates a bigger effect.

Misconception 3: "There's no force acting on the student while they're in the air, so they just float until gravity brings them back down."
Clarification: Gravity is the only significant force acting on the student while they're airborne. Gravity is constantly pulling them downward during the entire jump—from takeoff to landing. This is why the student slows down as they rise (gravity pulls against their upward motion) and then speeds up as they fall (gravity pulls in the same direction as their motion).

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## Extension Activities

1. Jump Height Challenge: Have students perform standing broad jumps and measure the horizontal distance. Then have them perform vertical jumps and measure how high they can reach on a wall. Students can graph their results and compare jump distances across the class, exploring how leg strength and technique affect distance.

2. Force Investigation with a Bathroom Scale: Have students stand on a bathroom scale (which measures the normal force pushing up). Ask them to predict what happens to the scale reading when they crouch to jump, during the jump, and when they land. Record the numbers and discuss why the reading changes—connecting it to Newton's Third Law.

3. Design a Jump Course: Challenge students to design an obstacle course with cones at different heights and distances. Have them predict which jumps will be hardest and why (based on distance, height, and required force). Test predictions and discuss how mass, muscle strength, and technique affect performance.

## Cross-Curricular Ideas

Math Connection: Graphing Jump Data
Have students conduct a jumping experiment where they measure how high each classmate can jump (using a wall or measuring tape). Record the data and create bar graphs or line plots showing the jump heights. Students can calculate the mean, median, and range of jumping heights across the class. This connects force and motion to data analysis and statistics.

ELA Connection: Procedural Writing and Instructions
Ask students to write step-by-step instructions for "How to Jump Over a Cone" or "How to Improve Your Jumping Ability." This requires them to explain the science concepts (force, gravity, muscle power) in clear, sequential language. Students can share their instructions with younger grades or create an illustrated how-to guide.

Social Studies Connection: Olympic Sports and Culture
Research jumping events in the Olympics (high jump, long jump, triple jump) and explore how different countries train their athletes. Discuss how jumping is valued differently across cultures and time periods. Students can create presentations comparing jumping sports from around the world and discuss what makes certain athletes successful.

Art Connection: Movement and Illustration
Have students create a series of drawings or a comic strip showing the five stages of a jump: preparation (crouch), takeoff, ascent, descent, and landing. They can annotate each stage with the forces at work (muscle force pushing down, ground pushing up, gravity pulling down). This visual representation helps solidify understanding of the invisible forces involved in jumping.

## STEM Career Connection

Physical Therapist
Physical therapists help people recover from injuries or improve their movement and strength. They understand how bones, muscles, and forces work together. If someone has trouble jumping or running after an injury, a physical therapist designs exercises to help them move safely again. They use knowledge of force and motion every day! Average Annual Salary: $92,000

Sports Engineer
Sports engineers design equipment like better sneakers, knee braces, or jumping platforms. They study how forces affect the human body during athletic activities like jumping and create products that help athletes perform better and stay safer. They combine physics, materials science, and creativity to solve problems in sports. Average Annual Salary: $72,000

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Biomechanist

Biomechanists study how the human body moves by analyzing forces, motion, and muscle activity. They might film athletes jumping and use computers to measure the forces involved, or they might study how gravity affects movement in different environments. Some biomechanists work with Olympic teams to help athletes jump higher and run faster through scientific training methods. Average Annual Salary: $85,000

## NGSS Connections

Performance Expectation:
5-PS2-1: Support an argument that the gravitational force exerted by Earth on objects is directed down.

Disciplinary Core Ideas:
- 5-PS2.A Forces and Motion: An object is pushed or pulled by a force, which can have a magnitude and direction. The direction and magnitude of forces on an object determine the changes that will occur.
- 5-PS2.B Types of Interactions: Objects in contact exert forces on each other (friction, normal forces). Some forces act at a distance (gravitational, magnetic, and electrostatic forces).

Crosscutting Concepts:
- Cause and Effect The student's muscle force causes motion; gravity causes the student to return to the ground.
- Systems and System Models The jumping system includes the student's muscles, bones, the ground, and gravity all working together.

## Science Vocabulary

* Force: A push or pull that makes something move, stop, or change direction.
* Gravity: An invisible force that pulls objects downward toward Earth.
* Acceleration: A change in how fast something is moving or the direction it is moving.
* Motion: A change in position; the act of moving from one place to another.
* Newton's Third Law: The rule that says for every action, there is an equal and opposite reaction.

## External Resources

Children's Books:
- Gravity by Jason Chin (simple explanations with illustrations of gravity in action)
- Forces Make Things Move by Kimberly Bradley (explores different types of forces through everyday examples)
- What Makes Things Move? by Kathleen Weidner Zoehfeld (beginner-friendly exploration of force and motion)

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