

## Photo Description



This image shows a large backhoe loader machine at work on a construction site. The machine has a long arm with a bucket on one end that can scoop up dirt and rocks. Two workers are operating and guiding the heavy equipment as it lifts and moves material. The powerful machine demonstrates how forces are used to move heavy objects that people alone could not lift.

## Scientific Phenomena

**Anchoring Phenomenon:** A backhoe loader using mechanical advantage to lift and move heavy loads that would be impossible for humans to move alone.

**Why This Happens (Scientific Explanation):**

The backhoe loader demonstrates balanced and unbalanced forces in action. When the machine's hydraulic arm pushes downward with great force, it creates an unbalanced force that lifts the heavy bucket full of dirt upward. The machine's engine provides energy that powers hydraulic fluid through tubes and cylinders. These cylinders push and pull mechanical arms, multiplying the force the operator applies. Without the machine, the dirt-filled bucket would remain on the ground because the downward force of gravity would be balanced with no upward force to overcome it. The backhoe creates an unbalanced force—a larger upward push than the downward pull of gravity—which causes the heavy load to move upward.

## Core Science Concepts

1. **Unbalanced Forces Create Motion:** When forces are unequal (one stronger than the other), objects move. The backhoe's powerful upward force is stronger than gravity's downward pull, so the bucket moves up.
2. **Balanced Forces Keep Objects Still:** When forces are equal and opposite, objects stay at rest or move at the same speed. When the backhoe holds the bucket steady in the air, the upward hydraulic force balances the downward force of gravity.
3. **Simple Machines Multiply Force:** The backhoe's arm acts like a lever and pulley system. These simple machines allow a smaller effort force (operator's input) to move a much larger load (the bucket of dirt).
4. **Energy Transfer:** The backhoe's engine converts fuel energy into mechanical energy that moves the hydraulic fluid, which then moves the bucket.

### Pedagogical Tip:

When teaching balanced versus unbalanced forces, use the backhoe as a concrete reference point. Ask students: "When is the bucket moving up? When is it still?" This helps them connect the abstract concept of forces to something they can see and understand. Having students physically act out forces—one child pushing one direction while another pushes the opposite way—reinforces these concepts kinesthetically before adding the backhoe example.

**UDL Suggestions:**

**Representation:** Provide labeled diagrams of the backhoe with arrows showing forces (use blue arrows for upward hydraulic force, red arrows for downward gravity). Some students may benefit from simplified versions showing just two arrows, while others explore more detailed force diagrams.

**Action & Expression:** Allow students to demonstrate understanding through multiple modalities: drawing force diagrams, acting out balanced/unbalanced forces with peers, explaining verbally, or building with construction toys. Provide sentence frames for students who need language support: "The bucket moves up because the \_\_\_\_\_ force is stronger than the \_\_\_\_\_ force."

**Engagement:** Connect to students' interests by showing videos of different heavy equipment (cranes, dump trucks, bulldozers) so all learners see forces in machines relevant to their experiences.

**Discussion Questions**

1. What forces do you see acting on the bucket of dirt? (Bloom's: Understand | DOK: 1)
2. Why do you think the backhoe machine is needed to move the bucket instead of workers just picking it up with their hands? (Bloom's: Analyze | DOK: 2)
3. If the backhoe operator wanted to hold the bucket completely still in the air, what would need to happen to the forces? (Bloom's: Apply | DOK: 2)
4. How might the backhoe be different if it had to move even heavier loads of dirt? (Bloom's: Evaluate | DOK: 3)

**Extension Activities****Activity 1: Force Pair Investigation**

Provide students with pairs of objects (a heavy book and a light pencil, for example). Have them practice pushing and pulling each object with different amounts of force. Ask: "When do you need more force?" and "What happens when you push harder?" Create a chart showing balanced versus unbalanced forces with student-generated examples.

**Activity 2: Build a Lever Crane**

Using craft sticks, straws, tape, and a paper cup, have students construct a simple lever machine similar to a backhoe arm. They can place weights (washers or blocks) in the cup and discover how moving the fulcrum (pivot point) changes how much force is needed to lift the load. This directly demonstrates mechanical advantage.

**Activity 3: Force Detective in the Playground**

Take students outdoors to identify balanced and unbalanced forces in action: children on a seesaw, swings moving, balls being kicked, or sliding down a slide. Have them sketch or describe each scenario, label the forces with arrows, and determine whether forces are balanced or unbalanced based on whether objects are moving.

**NGSS Connections****Performance Expectation:**

3-PS2-1: Plan and conduct an investigation to provide evidence that a pushed or pulled object moves in the direction of the push or pull.

**Disciplinary Core Ideas:**

- 3-PS2.A Forces and Motion - The patterns of an object's motion in various situations can be determined by the net force. An object that is not being pushed or pulled at all, or is being pushed or pulled upon by balanced forces, can be observed as stationary.
- 3-PS2.B Types of Interactions - Objects in contact exert forces on each other.

Crosscutting Concepts:

- Cause and Effect The backhoe's engine (cause) creates hydraulic force (effect) that lifts the bucket.
- Systems and System Models The backhoe is a system of interconnected parts working together to accomplish a task.

### Science Vocabulary

- \* Force: A push or pull that can make something move, stop, or change direction.
- \* Balanced Forces: Equal pushes or pulls from opposite directions that keep an object at rest or moving at the same speed.
- \* Unbalanced Forces: Pushes or pulls that are not equal, which cause an object to move or change how it's moving.
- \* Gravity: An invisible force that pulls objects downward toward Earth.
- \* Hydraulic: A system that uses liquid under pressure to create powerful movement in machines.
- \* Simple Machine: A tool that makes work easier by changing the size or direction of a force.

### External Resources

Children's Books:

- Mighty Machines by Kenneth Snelson (Simple introduction to construction equipment and how machines use forces)
- Push and Pull by DK Findout (Illustrated guide to forces in everyday life)
- Simple Machines by David Adler (Clear explanations of levers, pulleys, and how machines multiply force)

YouTube Videos:

- "What Are Forces? | Forces for Kids" - Crash Course Kids  
A clear, animated introduction to pushes, pulls, balanced, and unbalanced forces with everyday examples.  
<https://www.youtube.com/watch?v=iNZqLq8ZFF4>
- "Backhoe and Excavator Explained for Kids" - Learn Engineering Kids  
Shows how construction equipment uses hydraulics and simple machines to lift heavy loads, with clear visuals of forces in action.  
<https://www.youtube.com/watch?v=vdJXKleQIVE>