

Photo Description



A backhoe loader machine sits in a yard with its bucket and digging arm extended upward and outward. Two workers stand nearby observing the heavy equipment. The machine demonstrates how forces from an engine are used to lift, move, and control large objects that would be impossible to move by hand alone.

Scientific Phenomena

This image illustrates balanced and unbalanced forces in action. The backhoe loader's hydraulic system generates tremendous pushing and pulling forces that overcome the weight of soil, rocks, and debris. When the engine pushes hydraulic fluid through cylinders, it creates an unbalanced force that moves the bucket upward—stronger than gravity pulling down. When the operator stops applying force, gravity and friction create a balanced state, keeping the bucket steady. Without this machine applying unbalanced forces, heavy materials would simply stay in place, held down by Earth's gravitational pull.

Core Science Concepts

- * Force and Motion: A force is a push or pull that can change how an object moves or its shape. The backhoe applies forces to lift and move heavy objects.
- * Balanced vs. Unbalanced Forces: When forces are balanced, an object stays still or moves at the same speed. When forces are unbalanced, an object accelerates, speeds up, slows down, or changes direction. The backhoe creates unbalanced forces to lift the bucket.
- * Simple Machines: The backhoe's arm uses levers and hydraulic cylinders (simple machines) to multiply the force applied by the engine, making it possible to lift loads far heavier than a person could lift alone.
- * Work and Energy: The engine converts fuel into energy that does work—moving heavy materials. Energy is transferred from the machine to the load.

Pedagogical Tip:

Use a seesaw or lever demonstration with a ruler and pencil fulcrum to help students physically feel how simple machines multiply force. Have students try lifting a book from different distances along the lever to understand why the backhoe's long arm is so effective. This concrete experience deepens understanding of the abstract concept of mechanical advantage.

UDL Suggestions:

Provide multiple means of representation: Show videos of the backhoe in action alongside still photos. For kinesthetic learners, allow students to operate toy construction equipment or build lever systems with craft materials. For visual learners, use labeled diagrams showing force arrows pointing up (lift) and down (gravity). Consider pairing this lesson with a virtual field trip to a construction site or invite a local equipment operator to discuss forces and safety.

Discussion Questions

1. What forces do you see acting on the bucket in this picture? (Bloom's: Analyze | DOK: 2)
2. If the backhoe stopped pushing with its hydraulic arm, what would happen to the bucket? Why? (Bloom's: Predict | DOK: 2)
3. Why do you think the backhoe has such a long arm instead of a short, stubby arm? (Bloom's: Evaluate | DOK: 3)
4. Compare lifting a heavy rock with your hands versus using the backhoe. How are the forces different? (Bloom's: Compare | DOK: 3)

Extension Activities

1. Build a Lever System: Students construct a simple lever using a ruler, pencil fulcrum, and small weights (washers, blocks). They test how changing the fulcrum position affects the force needed to lift the weight. Connect this to how the backhoe's arm works as a series of levers.
2. Compare Machines: Create a poster or digital presentation comparing different machines that use unbalanced forces (cranes, pulleys, ramps, levers, hydraulic jacks). Students research how each multiplies force and present their findings to the class.
3. Design Challenge: Give students toy blocks or a sandbox and ask them to design a simple machine from craft materials (popsicle sticks, straws, tape) that can move or lift as much "dirt" (sand or small pebbles) as possible. Challenge them to explain which forces are balanced and unbalanced in their design.

NGSS Connections

Performance Expectation:

5-PS2-1: Support an argument that the gravitational force exerted by Earth on objects is downward.

Disciplinary Core Ideas:

- * 5-PS2.A Forces and Motion
- * 5-PS2.B Types of Interactions

Crosscutting Concepts:

- * Cause and Effect
- * Systems and System Models

Science Vocabulary

- * Force: A push or pull that can make something move, stop, or change direction.
- * Unbalanced Forces: Forces that are not equal, causing an object to move, speed up, slow down, or change direction.
- * Hydraulic: A system that uses pressurized liquid to create powerful pushing and pulling movements in machines.
- * Gravity: The invisible force that pulls objects downward toward Earth.
- * Mechanical Advantage: The benefit gained by using a simple machine—it allows you to lift heavier objects with less effort.
- * Load: The weight or object being lifted, moved, or carried by the machine.

External Resources

Children's Books:

Big Machines* by Byron Barton (introduces construction equipment in simple language)

Machines at Work* by Byron Barton (explores how machines use forces)

The Way Things Work Now* by Macaulay (engaging introduction to simple machines and forces)

YouTube Videos:

* "Simple Machines: Levers" by Crash Course Kids — Explains how levers multiply force using real-world examples. <https://www.youtube.com/watch?v=yKQUBSfQJhc>

* "How Hydraulics Work" by Animated Engines — Demonstrates hydraulic systems in kid-friendly language with clear animations. https://www.youtube.com/watch?v=fUXSMbC_bws