Balanced And Unbalanced Forces

4th Grade

Physical Science | Lesson Guide

Photo Description

This image shows a large construction machine called a backhoe loader with its mechanical arm (bucket) raised high in the air. A person stands beside the machine on a grassy property with trees and a house in the background. The backhoe is using hydraulic power to lift heavy materials—demonstrating how machines can apply forces to move and lift objects that would be too heavy for humans to move alone.

Scientific Phenomena

Anchoring Phenomenon: A backhoe loader lifting heavy loads using applied force and simple machines.

Why This Happens: The backhoe uses hydraulic pressure (fluid pushed through cylinders) to create a large force that moves the mechanical arm. This is an example of an applied force—a push or pull created by the machine's engine. The backhoe's arm acts as a lever (a simple machine), which multiplies the force applied, allowing the operator to lift objects much heavier than a human could lift. Without this applied force, gravity alone would keep the heavy materials on the ground. The machine works by converting engine power into hydraulic pressure, which then creates the force needed to overcome gravity and move the load.

Core Science Concepts

* Applied Forces: A force is a push or pull. The backhoe's engine creates an applied force through hydraulic pressure that moves the bucket and lifts materials against gravity.

* Simple Machines (Levers): The backhoe's arm works like a lever—a simple machine with a fulcrum (pivot point) that multiplies force. This allows a smaller effort to lift a much larger load.

* Gravity and Weight: Gravity constantly pulls objects downward. The backhoe must apply an upward force greater than the weight of the materials to lift them off the ground.

* Work and Energy: The backhoe does "work" by applying a force over a distance (lifting the bucket). This requires energy from the engine.

Pedagogical Tip:

When introducing this lesson, ask students to first try lifting a heavy object themselves (like a textbook stack), then discuss how the backhoe does the same job with less effort. This concrete experience helps them understand why simple machines matter in real life. This builds from their personal experience to the abstract concept.

UDL Suggestions:

Provide multiple means of representation: Show the photo, then show a simple diagram of a lever with labels. Allow students to choose between drawing, building with blocks, or role-playing to demonstrate their understanding of how the backhoe works. Some students may benefit from manipulating a simple lever tool (like a ruler on a pencil) to feel the mechanical advantage firsthand before discussing the backhoe.

Discussion Questions

1. What force is the backhoe using to lift the bucket full of dirt? (Bloom's: Understand | DOK: 1)

2. Why do you think the backhoe's arm is shaped like a long stick instead of being short and thick? How does the shape help it lift heavy objects? (Bloom's: Analyze | DOK: 2)

3. If a person tried to lift the same bucket of dirt that the backhoe lifted, what would happen? Why? (Bloom's: Analyze | DOK: 2)

4. If the backhoe's engine broke and couldn't pump hydraulic fluid anymore, what would happen to the bucket? Explain using what you know about gravity and forces. (Bloom's: Evaluate | DOK: 3)

Extension Activities

1. Build a Lever Machine: Provide students with rulers, pencils, and small objects of different weights (erasers, blocks). Have them create a simple lever by placing a ruler across a pencil (fulcrum) and experiment with lifting objects from different distances along the ruler. Students should discover that the farther the load is from the fulcrum, the harder it is to lift—and the closer it is, the easier. They can draw diagrams showing their findings.

2. Design a Lifting Machine: Provide students with building materials (straws, string, paper clips, plastic cups). Challenge them to design and build a simple machine that can lift a toy object (marble, small block) at least 6 inches off the ground using only these materials and a human hand for power. This requires them to apply their understanding of levers and simple machines. Students should sketch their design first, test it, and explain how their machine works using vocabulary from the lesson.

3. Compare Effort and Load: Set up stations where students use different tools (spoon, shovel, stick) to scoop sand or soil into a bucket. Have them record which tool required the least effort and which required the most. Discuss how the shape and length of each tool affects the force needed—introducing the concept that different simple machines require different amounts of effort depending on their design.

NGSS Connections

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

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

Disciplinary Core Ideas:
- 3-PS2.A Forces and Motion
- 4-PS3.A The Relationship Between Energy and Forces

Crosscutting Concepts:
- Cause and Effect
- Energy and Matter
- Systems and System Models

Science Vocabulary

* Force: A push or pull that can make something move, stop, or change direction.

* Applied Force: A push or pull made by a person or machine to move something.

* Lever: A simple machine made of a stiff bar that pivots on a point (called a fulcrum) to lift or move heavy objects.

* Gravity: The invisible force that pulls objects downward toward Earth.

* Hydraulic: A system that uses liquid (usually oil) pushed through tubes under pressure to create power and movement.

* Work: Using force to move an object over a distance.

External Resources

Children's Books:
- Simple Machines: Levers by David Adler (illustrated explanations of how levers work in everyday machines)
- Machines Go to Work by William Low (colorful pictures of construction machines and what they do)
- The Way Things Work by Macaulay (engaging diagrams explaining simple machines, especially levers)

YouTube Videos:
- "Simple Machines: Levers for Kids" – An animated explanation of how levers work with real-world examples including construction equipment. https://www.youtube.com/watch?v=jYDhPr_AXVA

- "How a Backhoe Works" – A clear, age-appropriate video showing the basic mechanics of backhoe operation and hydraulic systems. https://www.youtube.com/watch?v=Lqw1Yd7FhP8