Forms Of Energy

Physical Science | Lesson Guide

3rd Grade

Photo Description

This image shows a large yellow and orange diesel train engine next to a much smaller red sports car on railroad tracks. The train engine is labeled "UPY 2677" and displays "Building America" and "Ultra Low Emissions Diesel Genset Switcher" on its side. The contrast between the massive train and the tiny car clearly shows how different objects can have very different sizes, weights, and the amount of force needed to move them.

Scientific Phenomena

Anchoring Phenomenon: Why does it take much more force to move a heavy train than a light car?

Scientific Explanation: This image illustrates the relationship between mass, force, and motion. The train engine is significantly heavier than the car because it contains more matter (greater mass). According to Newton's Second Law of Motion, the amount of force required to move an object depends on both the object's mass and the acceleration desired. A diesel engine must produce enormous amounts of force to accelerate and move the train's massive weight, while a much smaller engine can move the lighter car. Both vehicles demonstrate how forces cause changes in motion, but the train requires far greater force due to its greater mass.

Core Science Concepts

1. Mass and Weight: Objects with more mass require more force to move them. The train has much greater mass than the car, so it needs a more powerful engine to generate the force necessary for motion.

2. Force and Motion: A force is a push or pull that can cause an object to start moving, stop moving, or change direction. Both vehicles use engines to generate the force that makes them move along the tracks.

3. Energy Transfer: The diesel engine converts chemical energy stored in fuel into mechanical energy (motion). The larger engine produces more energy to move the heavier train.

4. Balanced and Unbalanced Forces: When a vehicle is stationary, forces are balanced (no motion). When the engine produces force, unbalanced forces act on the vehicle, causing it to accelerate and move.

Pedagogical Tip:

When teaching about force and motion using this image, have students physically experience the concept by pushing objects of different weights (a pencil vs. a textbook). This kinesthetic experience helps Third Graders internalize that heavier objects require more force to move, making the abstract concept of mass and force tangible and memorable.

UDL Suggestions:

Provide multiple means of engagement by allowing students to choose how they demonstrate understanding: some students might draw labeled diagrams of forces acting on vehicles, others might act out the concept by role-playing as forces pushing objects, and others might use manipulatives (blocks of different sizes) to represent the train and car. This honors diverse learning preferences while addressing the same standard.

Zoom In / Zoom Out

Zoom In (Molecular/Atomic Level):
At the microscopic level, the diesel fuel molecules are being chemically burned inside the engine's cylinders. This combustion reaction breaks chemical bonds and releases energy as heat. This heat expands gases, which push pistons up and down, creating the mechanical force that ultimately moves the vehicle. The difference between the train's massive engine and the car's smaller engine is that more fuel molecules are being combusted per second in the train's engine, releasing more energy and creating more force.

Zoom Out (Transportation System & Society):
These two vehicles represent different solutions to the transportation challenge of moving people and cargo across vast distances. The train is designed to move extremely heavy loads (hundreds of tons of freight or many passengers) long distances efficiently, while the car moves a few people shorter distances. Both depend on the same physical principles (force, motion, energy) but are engineered differently based on their purposes. Together, they represent how understanding forces and motion allows humans to design and build systems that meet different transportation needs in modern society.

Discussion Questions

1. Why does the train engine need to be so much bigger and more powerful than the car's engine? (Bloom's: Analyze | DOK: 2)

2. If both vehicles have engines producing force, why would the car move faster than the train? (Bloom's: Analyze | DOK: 3)

3. What would happen to the train if its engine suddenly stopped working while it was moving? (Bloom's: Predict/Evaluate | DOK: 2)

4. How is the force that moves the car similar to and different from the force that moves the train? (Bloom's: Compare/Contrast | DOK: 3)

Potential Student Misconceptions

1. Misconception: "The car is smaller, so it's weaker and can't move as fast as the train."
   - Scientific Clarification: Size doesn't determine speed; it determines how much force is needed to move something. The train is slower because it's heavier, not because it's bigger. In fact, the sports car can likely travel much faster than the train because its lighter mass means its engine can accelerate it to higher speeds more easily.

2. Misconception: "The train moves because it's on tracks, not because of forces."
   - Scientific Clarification: The tracks don't make the train move—the engine's force makes it move. The tracks simply guide the direction of motion and reduce friction, making it easier for the engine's force to move the heavy train. Without an engine producing force, the train would stay still even on the tracks.

3. Misconception: "The bigger engine is always better."
   - Scientific Clarification: The train's larger engine isn't "better"—it's designed for a different job. The large engine is necessary because the train is so heavy. The car's smaller engine is perfectly suited for moving a lighter object. The right engine depends on what you need to move and how fast you need to move it.

Extension Activities

1. Push and Pull Comparison: Have students collect various classroom objects of different weights (erasers, textbooks, chairs, etc.). Ask them to predict how much force (effort) they'll need to push each object across a smooth floor. Have them push each object and record their observations. Compare results: Did heavier objects require more force? Create a class chart showing the relationship between an object's weight and the force needed to move it.

2. Force Measurement with Scales: Using simple spring scales or bathroom scales, have students measure how much force (in pounds or Newtons) is needed to pull various objects across the floor at a constant speed. Compare the force needed for different objects. Discuss why some objects require more force (greater mass, more friction) and connect this to why the train needs such a powerful engine.

3. Design a Vehicle Challenge: Provide students with craft materials (cardboard, straws, wheels, etc.) and ask them to design two different vehicles: one to carry a heavy load (like a toy train) and one to carry a light load (like a racing car). Have them build their vehicles and test which designs work best. Discuss how their designs reflect the differences between the train and car in the photo—heavier vehicles need stronger structures and more powerful engines.

Cross-Curricular Ideas

1. Math Connection: Measure and compare the lengths of the train engine and the car in the photo (using a ruler and proportional reasoning). Have students calculate how many times longer the train is than the car. Create bar graphs showing the relative sizes of different vehicles (train, car, truck, bus).

2. ELA Connection: Read books about trains or vehicles (see Resources section). Have students write descriptive paragraphs comparing the train and car, using specific details and sensory words. Create a "Forces in Motion" word bank for classroom writing activities.

3. Social Studies Connection: Research how trains and cars changed transportation and society. Discuss why trains were important for building America (as mentioned on the train in the photo). Compare transportation methods in your local community and how they help people and businesses.

4. Art Connection: Have students create labeled diagrams or posters showing the forces acting on the train and car (using arrows to represent force direction and size). Create a scale model drawing of the two vehicles showing their actual size difference, or paint/draw scenes showing different vehicles in motion with exaggerated force arrows.

STEM Career Connection

1. Mechanical Engineer: These professionals design engines and machines like the diesel engine in this train. They use their understanding of forces, motion, and energy to create engines that can move heavy objects efficiently. Mechanical engineers might work for train companies, car manufacturers, or equipment makers. Average Salary: $88,000–$95,000 USD annually.

2. Locomotive Engineer: This person operates the train, controlling the powerful forces generated by the diesel engine to safely move the train and its cargo along the tracks. They need to understand how forces affect motion so they can brake and accelerate safely. Average Salary: $60,000–$70,000 USD annually.

3. Automotive Engineer: These engineers design cars and other vehicles, figuring out how to make engines powerful enough to move the vehicle but also fuel-efficient. They apply the same principles of force and motion shown in this image but optimize designs for speed, safety, and efficiency. Average Salary: $85,000–$102,000 USD annually.

NGSS Connections

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.

- Relevance: This image demonstrates unbalanced forces (the engine's force causing the vehicles to move) and the effects on motion. Students can investigate how different amounts of force affect how objects move.
- DCIs: 3-PS2.A Forces and Motion
- CCCs: Cause and Effect, Scale Proportion and Quantity

3-PS2-2: Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion.

- Relevance: Students can observe that heavier objects (like the train) accelerate more slowly and move at different speeds than lighter objects (like the car), establishing a predictable pattern related to mass.
- DCIs: 3-PS2.A Forces and Motion
- CCCs: Patterns

Science Vocabulary

* Force: A push or pull that can make something move, stop, or change direction.
* Motion: When something changes position and moves from one place to another.
* Mass: The amount of matter (or "stuff") that an object contains; heavier objects have more mass.
* Engine: A machine that burns fuel to create force and make vehicles move.
* Friction: A force that slows down or stops objects from sliding past each other; smooth surfaces have less friction.
* Acceleration: When something speeds up, slows down, or changes direction because of a force acting on it.

External Resources

Children's Books:
- Little Blue Truck by Alice Schertle (focuses on vehicles and motion)
- The Little Engine That Could by Watty Piper (classic story about effort and force)
- Trains Go by Steve Light (explores different types of trains and their functions)