Friction

Physical Science | Engineering Design Process

Engineering Challenge

Visible Elements in Photo

- Modern electric light rail train (Metro brand) with articulated passenger cars
- Steel overhead electrical lines and support poles (catenary system)
- Pantograph arm connecting train roof to overhead wires
- Concrete track bed/platform surface
- Urban/industrial setting with fencing and vegetation in background

Reasonable Inferences

1. From overhead wires & pantograph arm – The train requires a continuous, elevated power source delivered through a sliding contact point; this means the pantograph must maintain consistent contact while the train moves freely along the track.

2. From articulated car design – The train's flexible middle section allows it to turn corners and navigate curves while remaining stable; weight distribution and flexible joints are critical to safe operation.

3. From track bed infrastructure – The system requires fixed, level pathways; the train's wheels must follow a precise route, suggesting alignment and rail geometry are fundamental to the design.

Engineering Task

K-2 Challenge:

Build a train that gets power from a wire above it. Use a string stretched between two chairs or desks as your "power line." Design a small car (use a block, cup, or cardboard tube) with a stick or straw touching the string. Can you pull your car along the ground while the stick stays touching the string the whole way?

3-5 Challenge:

Design a model overhead power delivery system (catenary system) for a train that must:
- Maintain contact between a pantograph arm and an overhead wire as the train moves at least 2 meters in a straight line
- Support the weight of a 500-gram load on the train car without the wire sagging more than 2 centimeters
- Navigate a 30-degree curve without losing electrical contact
- Use only string/wire, tape, wooden dowels or straws, and a small cardboard or foam car

EDP Phase Targeted

Ask / Define Problem

This phase fits because the photo shows an existing real-world solution (the light rail system) to an unstated transportation and power-delivery problem. Students must first identify the challenge: "How do we power a moving vehicle without dragging heavy cables?" This contextual understanding makes the design task meaningful, not arbitrary.

Suggested Materials

- String, fishing line, or electrical wire (for overhead lines and pantograph)
- Wooden dowels, plastic straws, or coat hangers (for pantograph arm and support poles)
- Cardboard tubes, foam blocks, or small wood blocks (for train car body)
- Tape (masking, electrical, or duct) and fasteners
- Small wheels or casters (optional, for smooth rolling)

Estimated Time

K-2: 30–40 minutes (design, build, test contact along one straight path)

3-5: 60–90 minutes (planning overhead geometry, building pantograph mechanism, testing multiple scenarios, refining alignment)

Why This Works for Teachers

This task directly addresses NGSS ETS1.A (Defining Engineering Problems) by having students identify constraints (weight, contact, movement) and criteria (continuous power delivery, structural integrity) from a real infrastructure system before building a solution.