Mechanical Energy

Physical Science | Engineering Design Process

Engineering Challenge

Visible Elements in Photo

- A white Ford utility truck with an extended cab
- A tall articulated boom/crane arm mounted on the truck bed, angled upward
- A pulley system with rope attached to the boom (visible rope and pulley mechanism)
- A person on the ground holding what appears to be a large spherical object (possibly a weather balloon or exercise ball)
- Dense green trees and grassy outdoor setting
- A cable or rope extending from the boom to the ground where the person is positioned

Reasonable Inferences

- From the boom arm and pulley system: The truck is designed to lift or lower heavy or awkwardly-shaped loads safely using mechanical advantage (pulleys and leverage reduce the force needed).
- From the person's stance and position: The load being lowered requires human guidance and control, suggesting that mechanical systems often need human direction to work precisely.
- From the outdoor setting: This is a real-world application where simple machines (levers, pulleys) solve practical problems in difficult terrain or tight spaces where hands alone wouldn't work.

Engineering Task

K-2 Challenge:

"Design a Lifting Helper"

Your job is to build a simple machine that helps lift a heavy object off the ground without using your arm muscles. Use a stick, string, and a paper cup. Can you design a system where pulling down on the string lifts the cup up? Test it with a small object inside the cup. Does your helper work smoothly, or does it get stuck?

3-5 Challenge:

"Engineer a Pulley System to Lift and Lower a Load Safely"

Your challenge: Design and build a pulley-and-rope system that can lift a 500-gram bag of sand at least 30 cm off the ground and lower it back down smoothly without dropping it. Your system must:
- Use at least one pulley (fixed or movable)
- Allow the operator to control the speed of lowering (not a free fall)
- Be strong enough to lift the load without the rope fraying or snapping
- Work from a single pull point

Success criteria: Load lifts to target height, descends in a controlled manner (takes at least 3 seconds to lower), and rope remains intact after 5 full lift-and-lower cycles.

EDP Phase Targeted

Ask / Define Problem — This phase is the best starting point because the photo shows a real-world need (lifting loads in outdoor work) but doesn't show students actively testing yet. Students should first identify why humans need simple machines (the problem: heavy objects are hard to lift), then imagine how pulleys and levers could help, before building prototypes.

Suggested Materials

- String or rope (clothesline or paracord works well)
- Wooden dowels or PVC pipes (for boom/frame structure)
- Paper or plastic cups, or small buckets
- Fixed pulleys (hardware store) or makeshift pulleys (rubber bands looped through pencils)
- Sandbags, rocks, or water bottles as loads (500 g to 2 kg range)
- Tape, zip ties, or clamps to secure components
- A sturdy table, ladder, or frame to mount the boom

Estimated Time

K–2: 40–50 minutes (15 min intro, 20 min build, 10–15 min test and troubleshoot)
3–5: Two 40-minute sessions (Session 1: design, planning, build; Session 2: test, measure results, refine)

Why This Works for Teachers

This task directly addresses NGSS ETS1.A (defining and delimiting engineering problems) and ETS1.B (developing solutions) by asking students to identify how simple machines solve real-world load-handling challenges, then prototype and test their own systems under measurable constraints.