Rope Work, Energy

Model how work changes a cart's mechanical energy

P.3.c "Use models to illustrate the relationship between the work performed on an object and the object's total mechanical energy."

NAME _____ DATE _____

1 READ AND MARK

Read it twice

YOUR JOB Underline each rope-work value, then circle the kinetic and potential energy values at the start, at the higher point, and at the end to compare work with changes in total mechanical energy.

A Cart on a Ramp

1. A cart moves on a smooth ramp while a person guides it with a rope. For the energy model, choose the cart and Earth together as the system. Its total mechanical energy is the cart's kinetic energy plus the gravitational potential energy of the cart-Earth pair. The rope is outside this system, so the rope can transfer energy into or out of it by doing work. Gravity acts within the chosen system, so do not count gravity's work as a second outside energy transfer. Assume friction and air resistance are negligible throughout the trip.

2. At the start, the moving cart has 20 joules (J) of kinetic energy and 10 J of gravitational potential energy. The person pulls the rope as the cart climbs, keeping its speed constant. Because the rope pulls in the direction of motion, it does +60 J of work on the cart-Earth system. A before-and-after energy model can use two labeled energy bars: one for kinetic energy and one for gravitational potential energy. At the higher point, kinetic energy is still 20 J, but potential energy is 70 J. The 60 J increase in total mechanical energy matches the rope's positive work.

3. Next, the person lets the cart roll down part of the ramp while holding the rope taut. The rope pulls uphill while the cart moves downhill, so the rope does -30 J of work on the system. The person keeps the cart's speed constant, leaving kinetic energy at 20 J; gravitational potential energy drops from 70 J to 40 J. A model of the entire trip starts with 30 J of mechanical energy and ends with 60 J. The two rope transfers, +60 J and -30 J, combine to +30 J, matching that overall energy change.

2 ANSWER WITH EVIDENCE

Use the passage

1. For the climb, write the starting and higher-point mechanical-energy totals. How does their difference compare with the rope's work?

2. Model the descent with a before-and-after pair of kinetic and potential energy values. Show how the change in their total matches the rope's work.

3. A student says the rope's +60 J of work and gravity's -60 J of work cancel during the climb, so mechanical energy stays at 30 J. Use the passage's system model to correct the claim.

4. Model the whole trip using the starting total, both rope-work values, and the ending total. What relationship does your model show?

3 YOUR TURN

Your own words

Invent a different low-friction motion situation and choose an object-Earth system. In four or five sentences, give its starting and ending kinetic and gravitational potential energies, name one external force and its signed work, and explain how your before-and-after energy totals match that work.

Rope Work, Energy

PART 1 · READ AND MARK

Underline each rope-work value, then circle the kinetic and potential energy values at the start, at the higher point, and at the end to compare work with changes in total mechanical energy. Accept any marking that follows this job and points at the right text.

PART 2 · ANSWERS

#	QUESTION	ANSWER
1	For the climb, write the starting and higher-point mechanical-energy totals. How does their difference compare with the rope's work?	**Start: 20 + 10 = 30 J. Higher point: 20 + 70 = 90 J. The 60 J increase equals the rope's +60 J of work.**
2	Model the descent with a before-and-after pair of kinetic and potential energy values. Show how the change in their total matches the rope's work.	**Before: 20 J kinetic + 70 J potential = 90 J. After: 20 J kinetic + 40 J potential = 60 J. The 30 J decrease matches the rope's -30 J of work.**
3	A student says the rope's +60 J of work and gravity's -60 J of work cancel during the climb, so mechanical energy stays at 30 J. Use the passage's system model to correct the claim.	**Gravity acts within the cart-Earth system, so its work is not a second outside transfer. Gravitational potential energy rises by 60 J, and total mechanical energy rises from 30 J to 90 J.**
4	Model the whole trip using the starting total, both rope-work values, and the ending total. What relationship does your model show?	**30 J + 60 J - 30 J = 60 J. The net rope work of +30 J equals the increase in total mechanical energy.**

PART 3 · YOUR TURN (SAMPLE ANSWER)

My system is a skateboard and Earth on a smooth downhill path. At the start, its kinetic energy is 10 J and its gravitational potential energy is 50 J, for a total of 60 J. A friend pushes the skateboard downhill and does +20 J of work on the system. At the end, its kinetic energy is 50 J and its gravitational potential energy is 30 J, for a total of 80 J, so the 20 J increase matches the friend's work.

Accept different energy values if the starting and ending totals differ by the stated signed external work. The chosen system must include Earth for gravitational potential energy.