

Separate teacher key | Energy transfers

For both learner levels. Free for teachers, families and individual learners. Keep this key separate until learners have attempted the questions. No curriculum alignment or learning-effectiveness claim is made.

Purpose and preparation

Middle school: build a surroundings-inclusive explanation through a sketch and revision. High school: examine system boundaries, qualify an ideal condition, and separate evidence from a proposed mechanism.

Prerequisites: describe slowing and identify objects; high school also distinguishes observation from inference. Use the vocabulary on student page 2.

Paper activity: one learner needs a pencil and printed pages; extra paper is optional. Read prediction page first, then the explanation. Draw a track with and without cloth, label predictions, plan comparison conditions, and discuss limits. No real trial or observation dataset is supplied. Safe conditions: remain paper-only; no marbles, cutters, heat, elevated tracks or moving objects are required. A physical build is outside this worksheet activity.

Facilitation and access

Ask: "Which objects have you counted?" "Is that a possibility or something measured?" "What else could change the catch?" Do not supply a heat amount. Solo learners can cover the key until the end. Siblings can make separate predictions before comparing drawings. A nonspecialist adult can read the model aloud and use the explanations below. Permit oral or dictated responses, enlarged printing, a labelled sketch in place of prose, and a second sheet. For extra challenge, ask what observation would challenge a prediction. Internet and the linked story are optional.

Teacher observation: listen for learners explaining where movement energy may go and naming missing evidence. Use their reasoning to choose a follow-up prompt; a completed page alone does not establish understanding.

Optional rabbit hole: original micro-lesson:

<https://thisworldexplained.com/okay-but/where-the-motion-energy-goes/> . Optional story: One More Take:

<https://thisworldexplained.com/okay-but/one-more-take/> . The story mentions real-track limits; it does not isolate or measure individual energy transfers. Both are optional: this worksheet works entirely on paper.

Middle-school answer reasoning

MS1. Accept a tentative idea with a reason; this is a prediction before instruction. After reading, the energy-disappeared claim should be revised: energy may be transferred to other objects or internal forms. Tempting misconception: stopping means no energy exists. Prompt: "What happens if we include the track and air?"

MS2. Accept sketches identifying marble, track and air; a receiving cup is also reasonable if present. Learners should consider objects beyond the marble. Accept questions about destinations or how to investigate them. A circle is a proposed accounting boundary, not evidence of a measured transfer.

MS3. Accept an arrow to track, air or a thermal-energy label involving marble and track. It should say possible, not measured. The causal explanation is that movement energy can decrease while energy exists in the wider account. Reject an arrow to "nothing" or a numerical share unsupported by data.

MS4. Accept a specific revision or a justified retained idea. The map contains no amounts, so arrow size cannot establish shares. If learners retain "gone," ask them to distinguish gone from movement from gone from the total account.

MS5. Cloth is a possible slowing feature; it may change interaction with the marble. Release conditions, joints or receiving-cup geometry can also affect a catch. Accept repeated with/without-cloth comparisons using comparable releases and track/cup arrangements, recording both catches and misses. A catch records an outcome, not heat or individual energy amounts. Cloth is not guaranteed to solve the design problem.

MS6. Include the book and desk, optionally nearby air. Sliding interaction can increase internal thermal energy in book and desk as movement decreases. No perceptible warming or measured distribution is required by the imagined description. Accept simpler wording such as "some movement energy can become heating in the objects," if qualified as a possible account rather than a measurement.

High-school answer reasoning

HS1. Initial ideas need reasons rather than a single predetermined phrase. Later, A conflicts with an account including surroundings: movement energy changing is not disappearance. B claims both a destination and all of an amount without measurements. A repaired account allows transfers involving marble, track and air without assigning measured shares. Accept other evidence-aware wording.

HS2. A boundary including marble, track and nearby air can account for transfers missed by a motion-only account. Tracking travelling and spinning alone excludes thermal/internal energy and surroundings. Accept additional receiving-container boundaries if stated; reject a claim that drawing a boundary measures transfers.

HS3. No measured amounts are represented; arrows also do not establish that each listed mechanism occurred on a particular run. "Impacts" describes an interaction, not a measured energy store. Repair: the map lists possible processes/destinations and requires observations or measurements for particular amounts. Equal-looking arrows do not mean equal energy.

HS4. Under ideal rolling without slipping on a stationary surface, the contact point does not move relative to that surface; static friction need not remove movement energy there. This qualifies "all friction." A real track may deform, permit skidding, include impacts and interact with air. The ideal assumptions do not prove which real mechanisms occurred or their amounts. Do not substitute "friction never transfers energy."

HS5. Accept planned comparisons holding release point/method, marble, track joints and receiving-cup geometry comparable while changing the cloth condition. Record catches and misses plus observable path/behaviour, not imaginary heat values. Repeated misses or unchanged outcomes may challenge a prediction that cloth improves catching. Results might support performance under the tested conditions; they cannot alone identify thermal energy amounts or guarantee the cause. Comparability and repetition strengthen a comparison but do not eliminate every alternative explanation.

HS6. A motion-only account can decrease while a book-plus-desk account includes increasing thermal/internal energy associated with sliding. Considering the wider account prevents disappearance reasoning. Without material or thermal measurements, slowing alone does not determine how energy is shared between book and desk. Accept cautious qualitative accounts; no percentages or temperature changes are supplied.

Takeaways and follow-through

Learner takeaway: name the account, distinguish possible transfers from measured ones, and explain why less movement is not vanished energy. An ideal comparison has assumptions; a real design needs observations. A catch can be useful without being an energy meter.

Common misconceptions across levels: all lost movement energy heats only the marble; every friction force removes energy; a cloth patch guarantees a catch; one success identifies the mechanism; diagram arrows encode measured shares. Ask learners to repair each using a condition or missing evidence, then refer to the question-specific reasoning.

Assessment use: MS1/MS4 show revision, MS2/MS3 show surroundings accounting, MS5 shows comparison limits and MS6 tests transfer. HS1/HS2 show boundary and claim reasoning, HS3/HS4 test model limits, HS5 tests evidence planning, and HS6 tests transfer. Accept defensible alternative wording. This is a facilitation guide, not a validated diagnostic instrument.

Optional reusable discovery

Optional rabbit hole: original micro-lesson:

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Evidence behind the explanation

Further reading: MIT OpenCourseWare, Classical Mechanics chapter 14, sections 14.7-14.8 (energy accounting and sliding friction); OpenStax University Physics Volume 1, 11.1 Rolling Motion (ideal rolling assumptions); Exploratorium, Marble Machines activity guide, pages 1-5 (slowing features and testing). These resources inform the explanation, not a measured result from this activity.

MIT original: https://ocw.mit.edu/courses/8-01sc-classical-mechanics-fall-2016/mit8_01scs22_chapter14.pdf

OpenStax original: <https://openstax.org/books/university-physics-volume-1/pages/11-1-rolling-motion>

Exploratorium original:

https://www.exploratorium.edu/sites/default/files/tinkering/files/Instructions/marblemachines_activity-guide.pdf

Teacher note: story events and planned worksheet scenarios are not empirical datasets. One More Take is linked as a mention of real-track limits, not a demonstration isolating this lesson's transfers. No physical experiment is necessary to finish either worksheet.