

Teacher key | Height into Motion

Separate answer guidance for the OBML-001 middle-school and high-school worksheets, candidate version 1. Free classroom and home copy. Keep this key separate from student sheets. It contains every numbered response and teaching route; it reports no measured learning outcomes.

Purpose, preparation and prerequisites

Observable goal: the learner uses marble-center endpoint heights to defend a gravitational-energy comparison and states a limit on a real catch prediction. Middle-school work emphasizes labelled vertical measurements and a single changed endpoint. High-school work adds two-claim evaluation, evidence strength, controlled investigation planning and preservation of a drop under a moved finish.

Prepare one level-appropriate worksheet and a pencil. No device, purchase, marble, cup, tools or ramp is required. Prerequisites: recognize higher/lower and follow a labelled sketch. Define vertical as straight up/down; endpoint as start or finish; gravitational energy as stored energy associated with position in the marble-Earth system; comparison constant as a condition deliberately kept unchanged.

Paper activity: measure the question

Setup: use the worksheet diagram. Steps: (1) invite MS01 or HS01 prediction before turning the page; (2) add vertical lines between the center-height guides; (3) read the supplied explanation; (4) revise the reason; (5) sketch changed endpoints for MS04 or HS05. Observe whether the learner uses endpoint separation rather than sloping distance. Ask "Where does your measurement begin and end?" before giving an answer.

Safety and limits: this is pencil-and-paper work; do not build a tall track, launch objects or use stairs/roads. No physical trial is required. Drawing heights shows a model relationship, not a measured speed or proof of cup retention. Accept a changed prediction; do not ask students to invent results.

Nonspecialist, single-learner and mixed-level routes

One learner can explain the two endpoint heights aloud to an adult, who asks "What changed? What stayed the same?" Siblings can choose different levels, then compare explanations without grading each other. For an easier entry, trace horizontal guides and point to their vertical separation before writing; an oral or large-print response can replace handwriting. For deeper work, use HS05 and compare model support with actual observation. Without a printer or device, copy the three center heights on paper and read the local explanation aloud; this retains the reasoning but adds no experimental evidence.

Two tempting misconceptions

Following a ramp with a ruler feels natural, so a learner may mistake travel distance for vertical height. Ask them to draw a straight-down line between center-height guides. A successful catch feels decisive, so a learner may treat it as a guarantee. Ask which track/cup conditions that one observation actually covered. Repetitions can reveal variation; they do not prove universality or remove every measurement bias.

Middle-school answers | MS01-MS05

MS01 | Prediction

Accept either initial prediction when a reason is supplied; this is an invitation, not a prior-knowledge test. After reading, B is the justified choice for less energy from the drop: its center is nearer vertically to the common finish. Accept "lower start" only when tied to that fixed finish. Do not treat "B always catches" as supported.

MS02 | Diagram and measurement

Both vertical lines run between a release-center height and the shared finish-center height. They show vertical separation, rather than the sloped travel distance. Accept lines drawn beside the ramp via dashed horizontal guides. A need not be marked with a measured length because the model is not to scale. Prompt "Could you turn your line into one that points straight down?" if the learner traces the ramp.

MS03 | Revised explanation and constants

B supplies less gravitational energy than A under the stated near-Earth same-marble, no-shove comparison. Accept a justified revision or a strengthened original explanation. Constants can include the marble, finish, ramp and release method; the release mark changes. Require two genuinely fixed conditions, rather than "everything stays the same."

MS04 | New endpoint

Less: raising the finish while keeping it below the same start reduces the vertical separation. A labelled sketch with a shorter separation or a clear verbal explanation is acceptable. The claim concerns energy supplied by the drop; it does not by itself rank real speeds or catch success. Ask "What happened to the distance between those two height lines?"

MS05 | Boundary

The comparison supports less gravitational energy supplied from the lower release, with the same marble and fixed finish. It does not guarantee any cup catch. Observe actual track travel and retention in the specific catch arrangement; do not invent results. Accept cup geometry, track changes, release consistency or repeated catches/misses as relevant concerns. A lower release can be a reasoned option to try, rather than a universal repair.

High-school answers | HS01-HS05

HS01 | Bounded prediction

Accept an initial choice with reasoning before the explanation. The supported later conclusion is B for less energy supplied by the drop. Use vertical separation of marble-center heights, holding the marble and finish/release method fixed. The drawing cannot supply measured energy, actual speed, travel time or certain cup retention. Distinguish a prediction from a reported observation.

HS02 | Measurement critique

Distance along the ramp includes horizontal travel as well as change in height. It is not the endpoint vertical separation. Repair by locating each marble center, extending horizontal height guides, and measuring straight vertically between the release and finish guides. Do not measure from a ramp surface at one end to a marble center at the other. Accept a labelled verbal method or sketch.

HS03 | Two claims

(a) Supported: the higher finish is closer vertically to the unchanged release, so the same marble has a smaller drop. (b) Unsupported: unchanged endpoint heights give unchanged gravitational-energy supply even if route length changes. This is an energy-from-gravity comparison, not proof of identical real speed, time or catches. Accept an explicit distinction between gravity and additional real-track transfers.

HS04 | Strength of evidence

No. One retained catch describes one run, not height as the only determinant or every possible cup. A useful plan compares two release marks with the same marble, track, finish/cup position and no-shove release method as stable as feasible; repeats both conditions and records every retention/escape and unusual event. Accept a different recorded response when it answers the stated question and is explicitly identified. Repeats reveal variation but do not prove a universal rule, isolate unheld conditions or eliminate systematic bias. This remains a paper proposal; no apparatus instructions or empirical results are supplied.

HS05 | Changed finish, preserved drop

Move the start down by the same vertical change as the finish, if the existing ramp allows such a release position. Old and new pairs then have equal center-height separation, giving the same gravitational-energy supply for the same marble near Earth. Accept sketches with equal vertical gaps, even if horizontal spacing differs. If such a start is unavailable, say the brief cannot be met by this ramp. Equal drop does not establish the real catch: the revised travel and cup arrangement need actual checks. No drawing earns credit for a made-up measurement or guaranteed success.

Discussion and feedback

Prediction: "Which mark would you try and why?" Explanation: "Which two heights does your line compare?" Transfer: "If the finish moves, what else must you know?" Listen for linked reasoning, rather than exact wording. A sound response identifies the changed endpoint, the held conditions and a supported conclusion; an advanced response also separates the model from a real-run observation.

Unexpected responses

If a learner reports that a real low release still missed, do not turn that into failure or deny the observation. Ask what changed, how release and cup position were recorded, and what the height model does and does not predict. A claimed experiment needs its own record; these worksheets include no measured dataset. Exact catch prediction remains unresolved without particular apparatus evidence.

Optional reusable reading

The source micro-lesson, Height into Motion, focuses on endpoint height. The linked One More Take story shows Quinn comparing release marks and adjusting a start when the finish changes. These are optional reading routes; the student sheets contain the needed explanation. Further route, spin, energy-transfer and fair-test concepts are separate questions, not assumed prerequisites.

Optional reading and sources

Height into Motion is the source micro-lesson for this worksheet. You can complete this activity offline using the explanation here.

One More Take: Quinn compares release marks, then adjusts the start when the finish moves. This story is optional.

[Read or revisit Height into Motion](#)

[Read or return to One More Take](#)

[MIT: Potential Energy and Conservation of Energy \(sections 14.2 and 14.4.1\)](#)

[OpenStax: Gravitational Potential Energy \(section 7.3\)](#)

Source scope for the facilitator

MIT sections 14.2 and 14.4.1 and OpenStax section 7.3 support the qualitative endpoint-height relationship. The existing reviewed lesson source map binds E01; the research package E06 supports comparison planning and repetition, with NIST handbook sections 5.1.1 and 2.1.1.4 and TN1297 Appendix D.1 as its separate methodological evidence. The fictional story is an application, not a laboratory dataset. This package introduces no numerical formula, measured times, curriculum certification or effectiveness claim.

[NIST: What is experimental design? \(5.1.1\)](#)

[NIST: Variability \(2.1.1.4\)](#)

[NIST TN1297: Measurement terminology \(Appendix D.1\)](#)