

A detour, or a brake?

Vertical Drop versus Distance | Middle school worksheet

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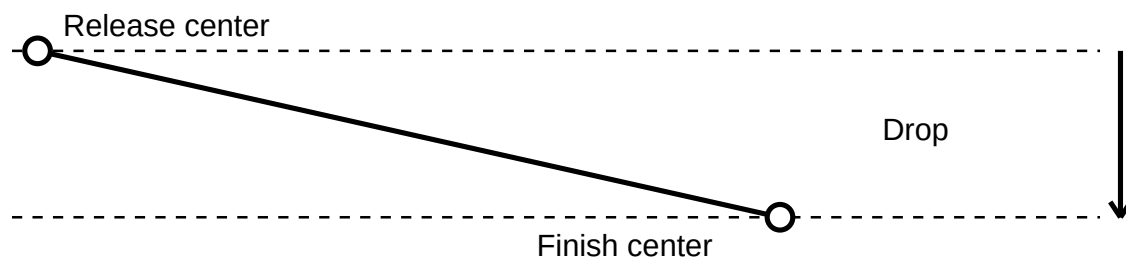
Name: _____ Date: _____

MS01 - Before the explanation

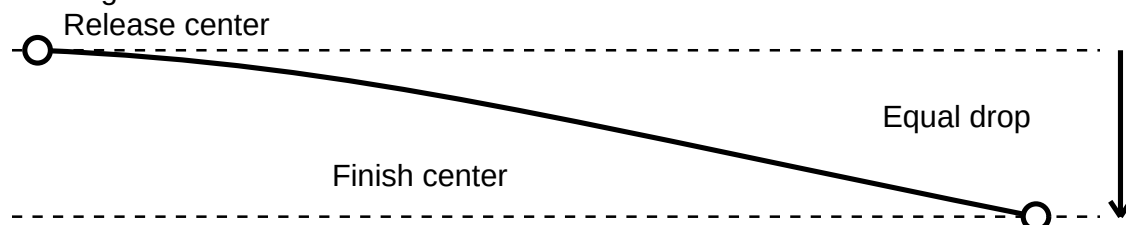
A friend adds a longer downhill route but keeps the same marble and the same start and finish heights. They say, "More track must mean a slower finish." What is your first prediction? Explain what you are assuming. You can revise it later.

MS01 My prediction and reason:

A - shorter route



B - longer route



Schematic side views; no measured scale. Dots mark center positions.

Two side-view route sketches: A is shorter, B is longer. Each marble center starts the same vertical distance above its finish center. Dotted horizontal guides mark these center heights. Vertical arrows show the drop; the route lines show travel distance. Schematic, not measured or to scale.

MS02 On the sketches, trace one route line and circle a vertical drop arrow. Explain which one measures travel distance and which one compares the start and finish center heights.

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Read the comparison

Vertical drop: the downward separation between the marble center at release and at the finish. Route length: distance along the track. Finish speed: how fast the marble center moves at the finish, rather than how long the whole trip takes. Ideal model: a deliberately simplified comparison with stated conditions.

For this ideal comparison near Earth: use the same marble (same shape and mass distribution), release from rest without a push, maintain rolling without skidding and contact with a stationary track, neglect track losses and air resistance, and add no powered push. The start-to-finish vertical drop supplies the same gravitational energy when it is equal. A rolling marble moves forward and spins. Keeping the same marble keeps the relationship between those motion energies fixed. With these conditions, equal drops give equal finish speeds. Route length alone does not determine that finish speed. Real tracks can change losses and contact; their results need checking.

MS03 Revisit MS01. Would you keep or change your prediction for the ideal comparison? Explain why, and name two conditions that make your answer possible.

MS04 Now the longer real route has a loose joint. Can you promise an equal finish speed or a successful catch just because the drop is equal? State what you would need to check.

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MS05 A paper plan moves the finish farther sideways but leaves its center height unchanged. Sketch the old and new center-height markers. Explain whether that sideways move alone changes the vertical drop.

MS05 - Sketch and explanation



Keep exploring, if you want

Everything needed for these questions is on the worksheet. Online reading is optional.

Source micro-lesson: Vertical Drop versus Distance

<https://thisworldexplained.com/okay-but/vertical-drop-versus-distance/>

Story application: One More Take - Quinn changes the layout and checks it

<https://thisworldexplained.com/okay-but/one-more-take/#quinn-layout-application>

Sources for the explanation

MIT: Potential Energy and Conservation of Energy - section 14.2

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

MIT: Rigid Body Dynamics - Example 21.4 (rolling cylinder model)

https://ocw.mit.edu/courses/8-01sc-classical-mechanics-fall-2016/mit8_01scs22_chapter21.pdf

OpenStax: Rolling Motion - energy and rolling conditions

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