

The Negative That Doesn't Mean Less

Teacher Notes — run it cold in 40 minutes

Motion Foundations · Lab Activity 2 · ConceptArc Education (FundaFirst HS) · fundafirsths.com

What you need: the same floor tape 0–8 m, a steady clap or metronome app, the activity file open (projector or shared link — offline once loaded, nothing to install, no accounts), one worksheet per student. **The one rule:** every prediction goes down in ink before any reveal. A changed answer beside a crossed-out one is the artefact you want.

Run of show — 40 minutes

0–5	Tape down (or re-use Activity 1's marks). Declare $+x$ aloud and write it on the board. Set the clap tempo; recruit two walkers.
5–14	The metronome walks (no screens). Walk 1: from 1 m, one metre toward larger x per clap, five claps. Walk 2: from 6 m, same tempo, toward smaller x . Class fills both columns, then 1(a)–(d). Run Script 1 between the walks. For 1(d), let the “–1 is less than +1” claim be voiced before anyone answers it.
14–22	Scene 1 (projected). Free-run the machine at $+2.5$ from 0.5 m — hops, table, line. Then the commit: worksheet Part 2 in ink before pressing “Show it on the machine”. The 16 m answer is the lesson: ask which number was treated as the seconds that passed. Re-set with $v = -1.5$ from $x_0 = 7$: the promise kept leftward (worksheet 2(b)).
22–29	Scene 2. Play to the freeze at the meeting. Commit Q1 and Q2 in ink; tap the tally; Reveal. Run Script 2 at the “B is slower” voters. Point at the two slope triangles: same window, different tilt and steepness.
29–35	Scene 4. One walker, three freezes, commits at each (worksheet Part 4). The twice-visited position ($x = 4.5$ m at two clock readings, two different velocities) is the quiet star — name it at the reveal.
35–40	Scene 3 (brisk, projected). Chord buttons left and right of $t = 4$ s; commit; Reveal; Script 3. Homework hook: send the file/link — Builder challenges 1–3, and Layer C for the students who ask for more.

Running short? Scene 3 becomes next lesson's opener — and Layer C moves with it. Never cut the ink-commit step. Individual-device rooms: students run Scenes 1, 2 and 4 self-paced (~22 min), then you run Scene 3 together.

The three scripts, in lesson order — plus one standing rule

Script 1 — The promise (the walks): Write $+1$ m/s on the board. Ask: *what does this DO in the next second?* Wait for the operational answer — “it moves one metre toward larger x ” — from a student before you say it. Then: *and –1 m/s?* Same tempo, the other way. A steady velocity is a kept promise about every second that follows — sign and all. (When the velocity is changing, as in Scene 3, it is still a promise — but only about the instant it belongs to.)

Script 2 — The number line is not a race (Scene 2): When someone ranks -2.5 below $+1.5$ (“B is slower — it's negative”), point at the track: *which walker covers more track each second?* Then the museum line: *speed is how fast — never negative; velocity is how fast and which way — signed.*

Script 3 — The limit (Scene 3): The averages on those buttons — each with 4 s at one end — never land ON 4. Ask: *then what IS the 4?* Give the word *limit* only after a student has pointed at the pattern from both columns. An instant has no duration; the velocity there is the value the shrinking averages agree on. **If a sharp student objects** that $3.9 \rightarrow 4.1$ gives exactly 4: they are right, and the reveal's last card says why — for this curve the two halves miss by equal and opposite amounts. Take the objection as a gift; it is the reason the question says *one end at $t = 4$ s*.

Standing rule — language guard (whole lesson): keep to *velocity, speed, direction, sign, clock reading*. When a pupil says the walker is “slowing down” on the return leg, take the gift: ask for its velocity now (-1 m/s) and its speed now (1 m/s) — today's words are *which way and how fast*; the story of speed changing over time belongs to the next unit.

Fit with the FundaFirst HS toolkit

- This activity is the classroom form of the $E3 \rightarrow E5 \rightarrow E6$ remediation block: run it when the class heatmap flags *average velocity* & ‘per’, *instantaneous velocity* and/or *speed-velocity-sign* — or before the diagnostic as a foundations lesson. It pairs with Lab Activity 1 (*The Graph That Looks Like a Hill*, the $E1 \rightarrow E4 \rightarrow E7$ block); the numbers here deliberately differ from the diagnostic's items.
- If your class has already sat the diagnostic, the matching worksheet sections (E3, E5, E6 of the Motion Foundations Remediation Worksheet) extend this lesson item-by-item; the traps by name are in the Mistake Museum (#3, #5, #6 — this activity's title is Entry #6).
- Keep the Scene 2 Q2 tally: which option drew the votes tells you which reading your class favours — the ranking error (D), the they-met-so-they-match error (A), or the sign-blind error (B).

Why this lesson exists (provenance)

Student difficulty with velocity as an operational rate, with the sign of velocity, and with instantaneous velocity is documented at high rates even in selective, calculus-based university cohorts: Trowbridge & McDermott, *Am. J. Phys.* 48, 1020 (1980) — the study this activity's comparison tasks descend from; teaching moves after Arons, *A Guide to Introductory Physics Teaching*, Ch. 2 (operational definition of velocity, the meaning of “per”); graph connections in McDermott, Rosenquist & van Zee, *Am. J. Phys.* 55 (1987) and Beichner, *Am. J. Phys.* 62, 750 (1994); real-time graphing gains in Thornton & Sokoloff, *Am. J. Phys.* 58, 858 (1990). The commit-before-reveal protocol follows the Interactive Lecture Demonstration tradition; step-level checking of student constructions goes back to the Andes physics tutor (VanLehn et al., *Int. J. Artificial Intelligence in Education* 15, 2005). What is FundaFirst-specific: the freezes, reveals and Builder challenges are wired to the same misconception bands as your class heatmap, so the lesson and the report speak one language.