KINEMATICS DAY 2: MOTION GRAPHS

WARMUP **Day 1 Review**

A walker goes 30 m east in 20 s, then 10 m west in 5 s. Find **(a)** total distance, **(b)** displacement, **(c)** average speed, and **(d)** average velocity (east = positive).

CALCULUS CORNER — SLOPES ARE RATES

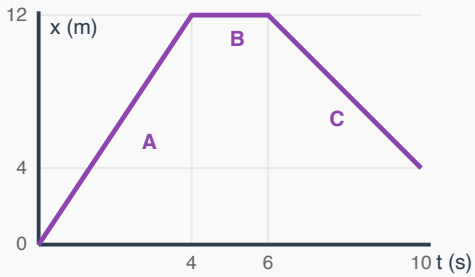
Every slope on an x-t graph is an average rate, $\Delta x/\Delta t$, and the units ride along: rise is meters, run is seconds, so every slope you compute today is in m/s. **Day 3 preview:** when the x-t graph *curves*, shrinking Δt turns the average rate into the instantaneous one — the derivative, $v = dx/dt$. Same units, same idea.

POSITION-TIME (X-T) GRAPHS

Slope = velocity.

- Straight line → constant velocity
- Flat (horizontal) → at rest
- Steeper → faster
- Sloping down → negative velocity (moving backward)

The graph is NOT a picture of the path — a downhill x-t line doesn't mean going downhill!



WE DO **Exercise 1: Read the Story**

Using the x-t graph above: **(a)** find the velocity during each segment A, B, and C. **(b)** What is the displacement for the whole 10 s? **(c)** What is the average velocity for the whole trip?

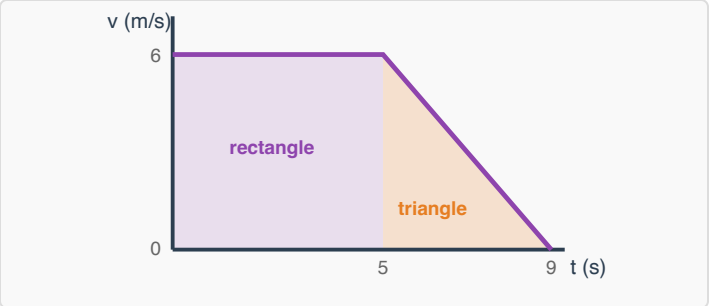
VELOCITY-TIME (V-T) GRAPHS

AREA = DISPLACEMENT

On a v-t graph, the area between the line and the time axis is the displacement.

- Area above the axis → positive displacement
- Area below the axis → negative displacement
- **The units prove it:** height × width = (m/s) × (s) = m — distance units
- Reading the height tells you the velocity at that instant

Break weird shapes into rectangles and triangles.



WE DO Exercise 2: Total the Areas

Using the v-t graph above: a bus travels at a constant 6 m/s for 5 s, then slows steadily to rest over the next 4 s. **(a)** Find the displacement during each piece — multiply the units along with the numbers (m/s × s = m). **(b)** Find the total displacement for all 9 s.

YOU DO Exercise 3: Signed Areas

An object moves at +4 m/s for 3 s, then at –2 m/s for 2 s. **(a)** Sketch the v-t graph in the box. **(b)** Find the displacement. **(c)** Find the total distance traveled. **(d)** Why are the answers to (b) and (c) different?

The #1 graph mistake: on a v-t graph, when the line touches the time axis the object is momentarily *at rest* — NOT back at the start. The graph never tells you "where" directly; only areas do.

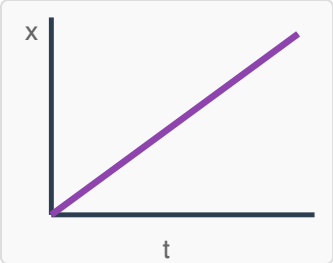
CALCULUS CORNER — AREAS ACCUMULATE

Think in strips: each second of motion adds $v \cdot \Delta t$ meters — (m/s)(s) = m — to a running total. The area under v-t is displacement *piling up*, strip by strip. **The units name what accumulates:** under an a-t graph each strip would be $(m/s^2)(s) = m/s$, so what piles up there is velocity change, not position. (Day 6 makes this the definition of the integral.)

MATCHING GRAPHS TO MOTION

YOU DO Exercise 4: Match Each Graph to Its Story

Each x-t graph below shows 6 s of motion. Write the letter of the matching description under each graph.



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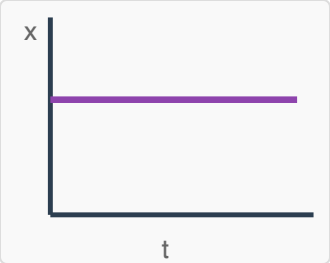

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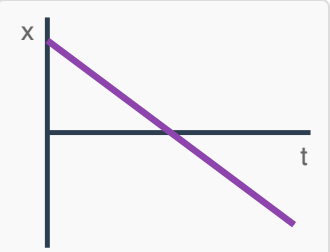

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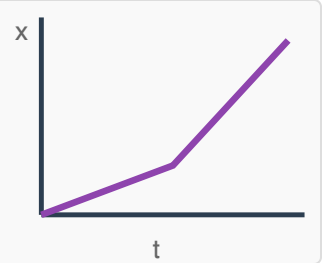

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A. Standing still, away from the origin. **B.** Walking forward at a steady pace. **C.** Walking slowly forward, then suddenly walking faster. **D.** Walking backward at a steady pace, passing the origin.

YOU DO Exercise 5: Story → Graph

An elevator moves up at 2 m/s for 4 s, holds still for 3 s, then moves down at 3 m/s for 2 s (up = positive). **(a)** Sketch the v-t graph. **(b)** Use areas to find the total displacement.

CALC Exercise 6: What Accumulates?

A graph shows a constant acceleration a = +2 m/s² for 3 s. Compute the area under it — multiply the units along with the numbers — and name the quantity you found. Why is it NOT a displacement?

PAPER PRACTICE

PRACTICE PROBLEMS

P1 Velocity From x-t

An x-t graph shows an object at x = +12 m at t = 2 s and at x = +4 m at t = 6 s, connected by a straight line. Find the velocity. Is the object moving toward or away from the origin?

P2 Area From v-t

A v-t graph shows velocity rising steadily from 0 to 8 m/s over 4 s (a straight ramp). Find the displacement. *Hint: it's a triangle.*

P3 Displacement vs Distance Again

An object moves at +5 m/s for 4 s, then at –5 m/s for 4 s. Using areas: **(a)** what is its displacement? **(b)** what distance did it travel? **(c)** where does it end up relative to its start?

P4 Graph Detective

A friend claims: "My x-t graph crosses the time axis, so I must have stopped." Explain what crossing the time axis on an x-t graph *actually* means, and describe what "stopped" really looks like on that graph.