KINEMATICS DAY 4: ACCELERATION & A-T GRAPHS

WARMUP Day 2 Review

A v-t graph shows an object at a constant +6 m/s for 3 s, then at rest for 2 s. **(a)** Sketch the graph. **(b)** Use area to find the displacement over all 5 s.

CALCULUS CORNER — ONE RUNG UP THE LADDER

Yesterday you differentiated x(t) to get v(t). Differentiate once more and you have acceleration: **$a = dv/dt = d^2x/dt^2$**. Today's $a = \Delta v/\Delta t$ is the *average* version of the same idea — exactly like the average-velocity ladder from Day 3, one rung up. The units audit themselves: (m/s)/s = m/s².

ACCELERATION

$a = \Delta v / \Delta t = (v_f - v_i) / \Delta t$ (units: m/s²)

Read m/s² as *"meters per second, every second"* — an acceleration of 3 m/s² means the velocity gains 3 m/s each second.

Acceleration has a sign, just like velocity. The sign of a tells you which direction velocity is being pushed — not whether the object is speeding up.

WE DO Exercise 1: Highway On-Ramp

A car accelerates from rest to 24 m/s in 8.0 s. Find its average acceleration.

YOU DO Exercise 2: Braking

A car moving at +30 m/s brakes to a stop in 5.0 s. Find its acceleration — including the sign.

SPEEDING UP OR SLOWING DOWN?

THE SIGN RULE

v and a have the SAME sign
→ speeding up

v and a have OPPOSITE signs
→ slowing down

Think of a as a push on the velocity: pushing the same way it's moving speeds it up; pushing against the motion slows it down.

Bust this myth now: "negative acceleration" does NOT automatically mean slowing down. An object moving in the negative direction with negative acceleration is *speeding up*. Always check both signs.

WE DO **Exercise 3: Moving Left, Pushed Right**

A cart moves at –8.0 m/s (leftward) while its acceleration is +2.0 m/s². **(a)** Is it speeding up or slowing down? **(b)** Find its velocity after 4.0 s using a = Δv/Δt. **(c)** Describe what happens after that moment if the acceleration continues.

YOU DO **Exercise 4: Fill the Table**

For each case, write "speeding up" or "slowing down."

	v = +12 m/s, a = +2 m/s²	v = +12 m/s, a = –2 m/s²	v = –12 m/s, a = –2 m/s²	v = –12 m/s, a = +2 m/s²
Result				

YOU DO **Exercise 5: Time to Stop**

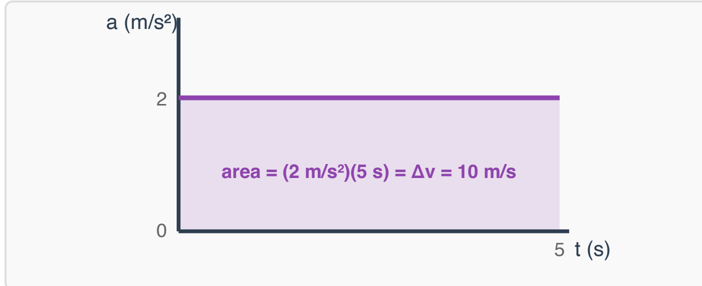
A truck moving at +18 m/s has acceleration –3.0 m/s². How long until it stops?

ACCELERATION-TIME (A-T) GRAPHS

AREA = CHANGE IN VELOCITY

On an a-t graph, the area between the line and the time axis is Δv.

- Area above the axis → velocity increases
- Area below the axis → velocity decreases
- **The units prove it:** height × width = (m/s²) × (s) = m/s — velocity units
- a-t graphs tell you how v *changes* — you still need v_i to know the final velocity



WE DO **Exercise 6: Area Plus Starting Velocity**

Using the a-t graph above (a = 2.0 m/s² for 5.0 s): the object starts at v = 4.0 m/s. **(a)** Find Δv from the area — multiply the units along with the numbers and show that they come out as m/s. **(b)** Find the final velocity.

YOU DO **Exercise 7: Three-Phase Motion**

An object starts from rest. Its acceleration is +3.0 m/s² for 4.0 s, then 0 for 3.0 s, then –2.0 m/s² for 5.0 s. Find the velocity at the end of **each** phase. *Then think: at the final moment, is the object moving forward or backward?*

PAPER PRACTICE

PRACTICE PROBLEMS

P1 Velocity After Braking

A car moving at +25 m/s has acceleration –5.0 m/s². Find its velocity after 3.0 s. *(Use $a = \Delta v/\Delta t$, solved for v_f.)*

P2 Triangle on an a-t Graph

An a-t graph shows acceleration rising steadily from 0 to 6.0 m/s² over 4.0 s (a straight ramp). Find the change in velocity. *Hint: it's a triangle.*

P3 Two Stages

A motorcycle starts at +5.0 m/s and accelerates at +2.0 m/s² for 6.0 s. **(a)** Find its final velocity. **(b)** Sketch the v-t graph for those 6 s.

P4 The Turnaround

A cart moves at –12 m/s with a constant acceleration of +3.0 m/s². **(a)** At what time is the cart momentarily at rest? **(b)** What is its velocity at t = 6.0 s? **(c)** In one or two sentences, describe the cart's full story: what it does before, at, and after the moment it stops.