

KINEMATICS DAY 3: ACCELERATION & A-T GRAPHS

WARMUP Day 2 Review

A v-t graph shows +6 m/s for 3 s, then 0 m/s for 2 s. What is the total displacement?

- ☐ A. 0 m ☐ B. 12 m
☐ C. 18 m ☐ D. 30 m

Check one → convince your neighbor in one sentence.

Physics in the Wild — "0 to 60" Is an Acceleration Brag: Car ads never quote velocity — every car eventually hits 60 mph (26.8 m/s). They quote *how fast you get there*. A Tesla Plaid does 0–60 in about 2.1 s, an acceleration of $\sim 13 \text{ m/s}^2$ — more than g ! That's why your head pins to the seat. Acceleration is the rate that velocity changes, and today it gets a number.

ACCELERATION

$$a = \Delta v / \Delta t = (v_f - v_i) / \Delta t \text{ (units: m/s}^2\text{)}$$

Read m/s^2 as "*meters per second, every second*" — an acceleration of 3 m/s^2 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 $a = \Delta v / \Delta t$. **(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/s ²	$v = +12$ m/s, $a = -2$ m/s ²	$v = -12$ m/s, $a = -2$ m/s ²	$v = -12$ m/s, $a = +2$ m/s ²
Result				

YOU DO Exercise 5: Time to Stop

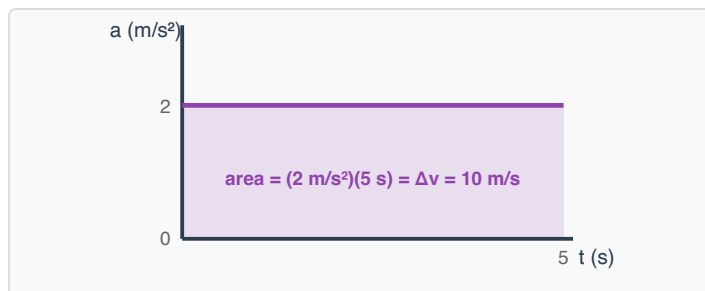
A truck moving at $+18$ m/s has acceleration -3.0 m/s². How long until it stops?

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 $\rightarrow$ velocity increases
- Area below the axis $\rightarrow$ velocity decreases
- **The units prove it:** height $\times$ width = $(\text{m/s}^2) \times (\text{s})$
= 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 ($a = 2.0 \text{ m/s}^2$ for 5.0 s): the object starts at $v = 4.0 \text{ m/s}$. **(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 $+3.0 \text{ m/s}^2$ for 4.0 s , then 0 for 3.0 s , then -2.0 m/s^2 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 $+25 \text{ m/s}$ has acceleration -5.0 m/s^2 . 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/s^2 over 4.0 s (a straight ramp). Find the change in velocity. *Hint: it's a triangle.*

P3 Two Stages

A motorcycle starts at $+5.0 \text{ m/s}$ and accelerates at $+2.0 \text{ m/s}^2$ 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 $+3.0 \text{ m/s}^2$. **(a)** At what time is the cart momentarily at rest? **(b)** What is its velocity at $t = 6.0 \text{ s}$? **(c)** In one or two sentences, describe the cart's full story: what it does before, at, and after the moment it stops.