4.2b / Speed: Speeding Up and Slowing Down

Watch the lesson ➤

Speed, and when a particle speeds up or slows down · Part 2

Learning goal

Tell when a particle speeds up or slows down from the signs of v and a at the same time, from a formula or a velocity graph.

Key ideas

01 $a = v'$ is how fast v changes: $a = -2$ means v goes down 2 each second. With $v = -5$ and $a = -2$, is it slowing down? $a < 0$ is not the brakes.

02 Speed is $|v|$, no direction; a speedometer is never **negative**. $v = -5, -7, -9$: speed 5, 7, 9, speeding **up**. Moving left and pushed left: faster. Start at $v = 5$ with the same a: 5, 3, 1, slowing; moving right, pushed left: slower.

03 Same signs of v and a: speeding up. Opposite: slowing down (a tug of war). On a velocity graph: away from the axis, speeding up; toward the axis, slowing down.

04 AP: "$v(1) < 0$ and $a(1) < 0$, the same signs, so the **speed** is increasing at $t = 1$." One sign alone is not enough.

Remember

speed
$|v(t)|$: how fast, without the direction.

speeding up
The speed is increasing: v and a have the same sign.

Class notes

4.2b / Write it clearly

What earns the point on the AP Exam, and the mistakes that lose it.

Common mistakes

The mistake code is used in the answers and in My Mistakes

01 a < 0 does not mean slowing down

Code M3

✗ $a(2) < 0$, so the particle is slowing down at $t = 2$.

✓ Check $v(2)$ too. If $v(2) < 0$ as well, the signs agree and the particle is speeding up.

4.2b / Guided examples

Watch, pause, and write the reasoning. Full solutions are in the video.

Problem types

Read the problem, name the type, then use its method

Type	Method	Problems
Speeding up or slowing down at one time (signs of v and a)	Find $v(t)$ and $a(t)$ at the same t. Same signs: speeding up. Opposite: slowing down.	E01, E03 · Practice 1, 4
Intervals where the speed increases	Sign chart for v and for a; keep the intervals where the signs agree.	Practice 2, 5
Speed from a velocity graph	Moving away from the axis: speeding up. Moving toward the axis: slowing down.	E02 · Practice 3

Example 01

Video · E01

A particle moves along a line with velocity $v(t) = t^2 - 5t + 4$ for $0 < t < 6$.
(a) At $t = 3$, is the speed increasing or decreasing? Justify.
(b) On what intervals is the speed increasing? Justify.

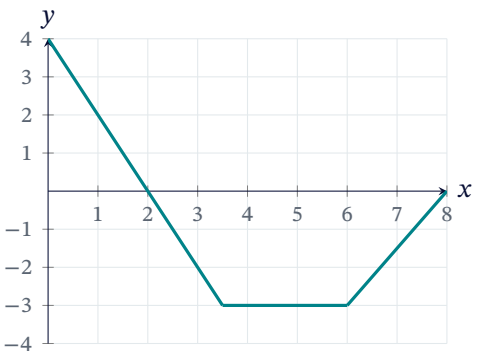
> Signs of v and $a = v'$ at the same time.

Example 02

Video · E02

The graph of the velocity $v(t)$ of a particle is shown for $0 \le t \le 8$. On which interval is the speed of the particle increasing?

> Away from the axis means faster.



A. $0 < t < 2$
B. $2 < t < 3.5$
C. $3.5 < t < 6$
D. $6 < t < 8$

Example 03

Video · E03

A particle moves along a line with velocity $v(t) = e^{-t}(t-2)$. At $t = 1$, the particle is

> The sign of $v(1)$, then the sign of $a(1)$.

A. moving left and speeding up
B. moving left and slowing down
C. moving right and speeding up
D. moving right and slowing down

VIDEO COMPLETE Check your example answers at the end of this booklet.

4.2b / Example answers

Speed: Speeding Up and Slowing Down

E01 (a) decreasing: $v(3) = -2 < 0$ and $a(3) = 1 > 0$, opposite signs; (b) $\left(1, \frac{5}{2}\right)$ and $(4, 6)$

E02 (B)

E03 (B)