What Is Acceleration? Why It's 180, Not 20

Physics with Tiaotiao 跳跳 · Kinematics · High School Physics

Study sheet for the video "What Is Acceleration?": key ideas, practice questions, answers

Matches: NCERT Class 11 Ch 2 Motion in a Straight Line · FSc Part 1 Ch 3 Motion and Force · AS & A Level 9702 · WAEC/JAMB · HSC · College Physics · AP Physics 1 Unit 1

Key ideas

Change and rate of change are different. **Change** tells you how much it changed. **Rate of change** = change ÷ time interval. It tells you how fast it changed.
A large change means a lot has changed, but not necessarily fast. A large rate of change means it changes fast, but not necessarily by a lot. A large change over an extremely long time gives a small rate of change.

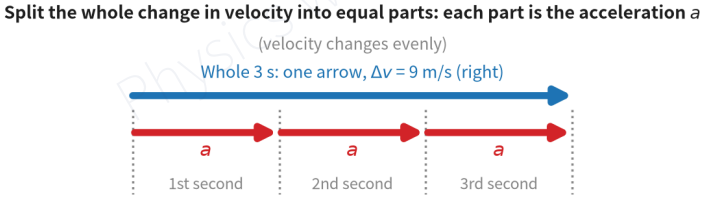
Acceleration is the rate of change of velocity. **$a = \Delta v / \Delta t$**, where a is the acceleration, Δv is the change in velocity and Δt is the time taken. The unit is m/s^2, because Δv is in m/s and Δt is in s.
Don't be fooled by the name. It can describe how fast velocity **increases** or how fast it **decreases**.
Example: velocity changes by +2, +10 and +1 m/s in 3 seconds, a total of +13 m/s. Then a = 13 m/s ÷ 3 s ≈ 4.3 m/s^2. This is the **average** acceleration. Even if the velocity changes unevenly, you get the average change in velocity per second.

Who improved faster? Change alone is not enough: divide by time.

Score	Change and time taken	Points gained per day
Tiaotiao	Change +10 points	10 points
70 → 80	Time 10 days	10 days
Qi Xiaoyu	Change +30 points	30 points
60 → 90	Time 120 days	120 days

Change ÷ time interval = rate of change. It shows how fast the change is.

Acceleration is a vector (has both magnitude and direction). Its direction is the **same as Δv**. Think of Δv as one arrow. Split it into equal parts by time. If velocity changes evenly, each small arrow is the acceleration, and each points the same way as the big arrow.



Small arrows point the same way as the big arrow: *a* has the same direction as Δ*v*

Steps on a straight line. The core is finding Δv.
1. Choose the positive direction.
2. Calculate $\Delta v = v_t - v_0$.
3. Use $a = \Delta v / \Delta t$ to find the acceleration.

The sign of a only shows direction. To compare magnitudes, compare the numbers only.

Practice

Try these before checking the answers on the next page.

1. Xiao Zhang is watching an F1 race. As a car flashes past, he exclaims "So fast!". At the finish the car brakes suddenly and stops, and he exclaims "So fast!" again. Which statement is correct? ( )

A. The first "fast" means high speed; the second "fast" also means high speed

B. The first "fast" means high speed; the second "fast" means velocity changes quickly

C. The first "fast" means velocity changes quickly; the second "fast" also means velocity changes quickly

D. The first "fast" means a large change in velocity; the second "fast" also means a large change in velocity

Answer: _____ Reason:

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2. Consider these situations:

① A car turns at an intersection while its speedometer reading stays constant.

② A rocket just after ignition, about to lift off.

③ A truck moving in a straight line at high speed on a highway brakes hard to avoid an accident.

④ A maglev train (a very fast train that floats on magnets) runs at high speed on its track.

Which of the following statements about these situations is correct? ( )

A. The speedometer reading is constant, so the car's velocity is constant as it turns

B. The rocket has not started to move, so its acceleration must be zero

C. While the truck brakes hard, its change in velocity is large, and its acceleration is also large

D. The maglev train moves at high speed, so its acceleration must also be large

Answer: _____ Reason:

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3. A ball hits a wall horizontally at 10 m/s. After 0.1 s of contact with the wall, it bounces back along the same straight line at 8 m/s. What is the ball's acceleration during the collision? ( )

A. 20 m/s^2, perpendicular to the wall, inward B. 20 m/s^2, perpendicular to the wall, outward

C. 180 m/s^2, perpendicular to the wall, inward D. 180 m/s^2, perpendicular to the wall, outward

Answer: _____ Working:

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4. An object's initial velocity is 6 m/s. After 10 s, the magnitude of its velocity is 20 m/s. The magnitude of its acceleration could be ( ) (more than one may be correct)

A. 0.8 m/s^2 B. 1.4 m/s^2 C. 2.0 m/s^2 D. 2.6 m/s^2

Answer: _____ Working:

Answers and explanations

Tap a blue time to jump to the part of the video that explains the question.

1. B. Everyday "fast" can mean high speed, or velocity changing quickly. High speed does not mean speeding up: the car can move at a constant, very high speed and flash past. So the first "fast" means high speed. Braking from a very high speed to a stop at once means the velocity changes quickly. So the second "fast" means velocity changes quickly.

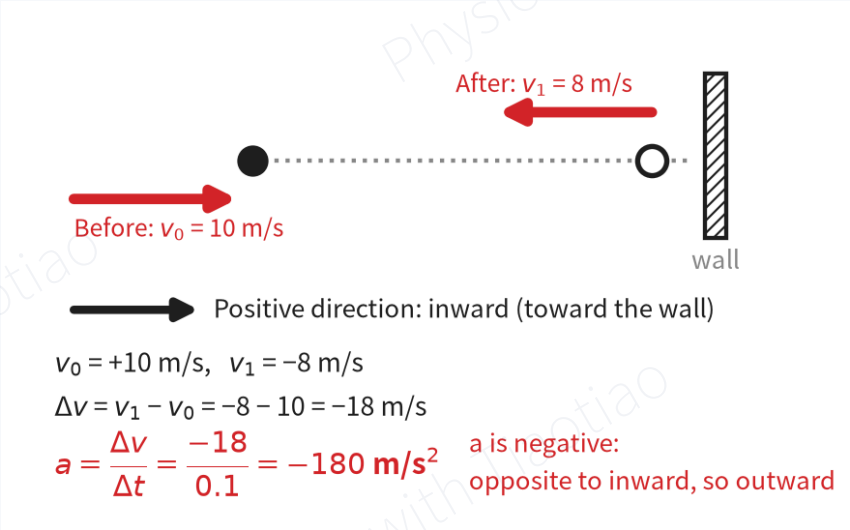
▶ **Watch 14:51, Example 1**

2. C. A is wrong: the speedometer shows only the speed (the magnitude of velocity). Velocity is a vector, and a turning car changes direction, so its velocity changes. B is wrong: the rocket has only an initial velocity of zero. After 0.1 s its velocity may be 100 m/s, and then a = (100 − 0) / 0.1 is not zero. C is correct: hard braking means a large change in velocity in an extremely short time, so the rate of change, a, is large. D is wrong: a maglev train is fast but usually keeps a constant velocity, so a = 0.

A large change does not mean a large rate of change. A large change in an extremely short time does.

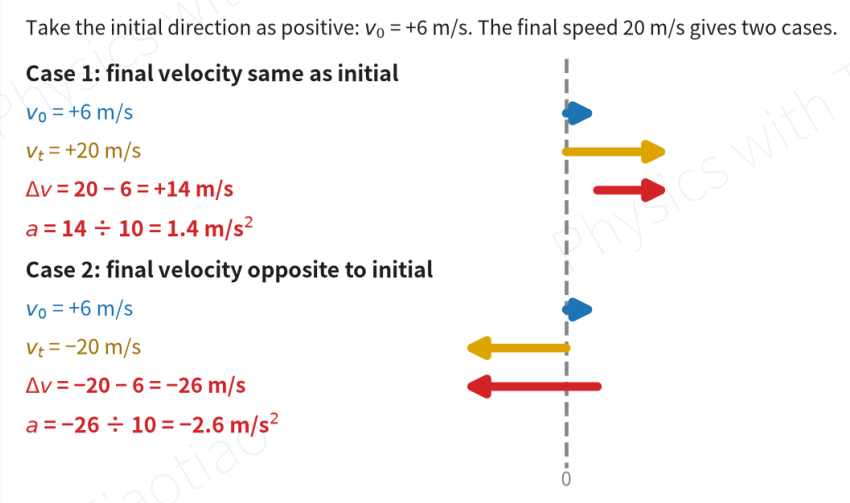
▶ **Watch 16:27, Example 2**

3. D. Take inward (toward the wall) as positive. v_0 = +10 m/s and v_1 = −8 m/s. Δv = −8 − 10 = −18 m/s. a = Δv / Δt = −18 / 0.1 = −180 m/s². The magnitude is 180 m/s². The sign of a is negative, so it is opposite to the positive direction (inward). It points outward.



▶ **Watch 25:48, Example 3**

4. B and D. Take the direction of the initial velocity as positive, so $v_0 = +6$ m/s. Only the magnitude of the final velocity is given, so there are two cases. ① Same direction: $v_t = +20$ m/s, $\Delta v = 20 - 6 = 14$ m/s, $a = 14 / 10 = 1.4$ m/s² (B). ② Opposite direction: $v_t = -20$ m/s, $\Delta v = -20 - 6 = -26$ m/s, $a = -26 / 10 = -2.6$ m/s². The magnitude is 2.6 (D).



The sign of a only shows direction. Compare magnitudes by the number only.

▶ **Watch 27:30, Example 4**

One-line summary

Acceleration is the rate of change of velocity, a = Δv / Δt, and it points the same way as Δv: pick a positive direction, find Δv, then divide by Δt.

Key terms

Term	Meaning	Chinese
acceleration (a)	rate of change of velocity, a = Δv / Δt	加速度 jiāsùdù
rate of change	change per unit time: how fast it changes	变化率 biànhuàlǜ
change in velocity (Δv)	final velocity minus initial velocity	速度变化量 sùdù biànhuàliàng
average acceleration	change in velocity per second, averaged over the interval	平均加速度 píngjūn jiāsùdù
vector	has both magnitude and direction	矢量 shǐliàng
positive direction	the direction you choose to call +	正方向 zhèng fāngxiàng
magnitude	the number part, without direction	大小 dàxiǎo