Speeding Up or Slowing Down? Check a and v

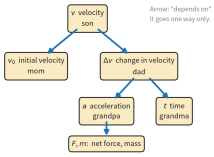
Physics with Tiaotiao 跳跳 · Kinematics · High School Physics

Study sheet for the video "Speeding Up or Slowing Down?": 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

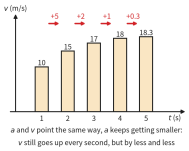
Key ideas

"Depends on" means this: hold everything else fixed. If you change A and B must change with you, then B **depends on** A.
$v = v_0 + \Delta v$. So v depends on v_0 (initial velocity) and Δv. Δv depends on a and the time t. a depends only on the net force F and the mass m (you learn this later).
Think of a family tree: v is the son, v_0 is mom, Δv is dad. A cause can affect its effect, but not the other way round: "I look like my dad", not "my dad looks like me".



How a, v and Δv relate. v depends on a, but a alone cannot decide v, because v also depends on v_0. a does not depend on v or on Δv. Δv depends on a: a decides the direction of Δv, but not its magnitude, because that also depends on t.

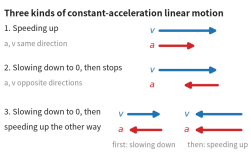
Speeding up or slowing down: look at the directions of a and v together. Same direction: speeding up. Opposite directions: slowing down. Neither v alone nor a alone is enough.
It does not matter whether a gets bigger or smaller. If a and v are opposite, v decreases even when a increases (faster and faster). If a and v are the same way, v increases even when a decreases (more and more slowly).
Example with made-up numbers: v = 10, 15, 17, 18, 18.3 m/s at t = 1 to 5 s. The car speeds up to the right while a keeps getting smaller. When a reaches 0, the velocity stops changing: constant velocity.



a and *v* point the same way, *a* keeps getting smaller: *v* still goes up every second, but by less and less

Three core statements.
1. If a = 0, the object is not necessarily at rest. It may be in uniform straight-line motion.
2. If you know only whether a increases or decreases, you cannot tell whether v increases or decreases.
3. If you know only the direction of a, you cannot tell the direction of v. Say a points right: if v points right, it speeds up; if v points left, it slows down.

Constant-acceleration linear motion has three kinds. When a and v are opposite, the motion has two stages: stage 1 slows down until v = 0. At v = 0 the object stops for an instant, but a is still there, so it turns around and speeds up the other way (stage 2: a and v point the same way).

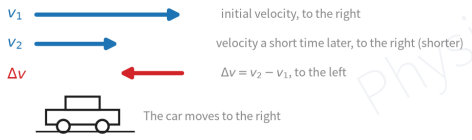


Practice

1. Which statement about the expression $a = \Delta v / \Delta t$ is correct? ( ) Answer: _____

A. $\Delta v / \Delta t$ is called the rate of change of velocity, that is, the magnitude of the change in velocity
B. The direction of Δv is not necessarily the same as the direction of a
C. As long as velocity changes, $\Delta v / \Delta t$ is definitely not 0
D. Acceleration a is directly proportional to Δv and inversely proportional to Δt

2. A car moves rightward along a straight line. Its original velocity is v_1; after a short time interval it becomes v_2. Δv is the change in velocity. From the figure, we can tell ( ) Answer: _____



A. The car is speeding up in a straight line
B. The car's acceleration points in the same direction as v_1
C. The car's acceleration points opposite to v_1
D. The car's acceleration points opposite to Δv

3. Decide whether each statement is true (T) or false (F).

① Acceleration is 0, so velocity must be 0
② A larger change in velocity means a larger acceleration
③ The greater an object's rate of change of velocity, the greater its acceleration
④ If the direction of velocity stays the same, the direction of acceleration stays the same too
⑤ If the direction of the change in velocity stays the same, acceleration stays the same too

Answers: ① ___ ② ___ ③ ___ ④ ___ ⑤ ___ Reason:

_____

4. Objects 1 and 2 move along the same straight line. The acceleration of Object 1 is 3 m/s^2 and that of Object 2 is −4 m/s^2. Which statement is correct? ( ) Answer: _____

A. Object 1 must be speeding up and Object 2 must be slowing down
B. The direction of motion of Object 1 must be opposite to that of Object 2
C. The velocity of Object 1 must change more slowly than that of Object 2
D. The acceleration of Object 1 is greater than that of Object 2

5. Xiao Zhang reads in the news that, since housing-price controls were introduced, home prices in some cities across the country have for a while kept rising but more slowly. Xiao Gang compares prices rising to speeding up in motion, and prices falling to slowing down. By this analogy, prices rising more slowly is like which of the following in motion? ( ) Answer: _____

A. Velocity increases, acceleration increases
B. Velocity increases, acceleration decreases
C. Velocity decreases, acceleration decreases
D. Velocity decreases, acceleration increases

6. Which of the following relationships between velocity and acceleration can exist? ( ) Answer: _____

A. Velocity points east and is decreasing; acceleration points west and is increasing
B. Velocity points east and is decreasing; acceleration points east and is increasing
C. Velocity points east and is increasing; acceleration points west and is increasing
D. Velocity points east and is increasing; acceleration points west and is decreasing

7. Hengshui High School, Hebei · 2014–15, Grade 10, first term Answer: _____
Which statement about the relationship between velocity and acceleration is correct? ( )

A. An object with zero acceleration must have zero velocity
B. When acceleration decreases, velocity must decrease
C. When acceleration decreases, velocity must increase
D. The greater an object's acceleration, the faster its velocity changes

8. Yinchuan No. 1 High School, Ningxia · 2017–18, Grade 10, first term Answer: _____
Which of the following statements is incorrect? ( )

A. An object has an eastward acceleration, yet its velocity points west.
B. An object moves with zero acceleration, so its velocity must be zero.
C. Comparing two objects, one has a larger change in velocity yet a smaller acceleration (Object 1: 0 → 10 m/s in 1000 s. Object 2: 0 → 5 m/s in 1 s.)
D. In straight-line motion, the acceleration in the later stage is smaller than in the earlier stage, yet the velocity is larger.

9. Tianjin Yaohua High School · 2019–20, Grade 10, first term Answer: _____
Which of the following statements is correct? ( )

A. An object with zero acceleration must be at rest
B. If an object's acceleration gradually decreases, its velocity may gradually increase
C. If an object's acceleration gradually increases, its velocity must also increase
D. When an object's acceleration is zero, its speed may be very high; when its speed is zero, its acceleration cannot be very large

10. 2019–20 100-School Alliance, Grade 10, first term Answer: _____
A particle moves in a straight line with its direction of velocity unchanged. During this motion ( )

A. If acceleration and velocity are in the same direction, when the acceleration gradually decreases to zero, the velocity reaches its minimum
B. If acceleration and velocity are in the same direction, when the acceleration gradually decreases to zero, the velocity reaches its maximum
C. If acceleration and velocity are in the same direction, when the acceleration gradually decreases to zero, the displacement will stop increasing
D. If acceleration and velocity are in opposite directions, when the acceleration gradually decreases to zero, the displacement reaches its minimum

11. Hengshui High School, Hebei · 2015–16, Grade 10, first term Answer: _____
A particle moves in a straight line. At $t = t_0$, $s > 0$, $v > 0$, $a > 0$. After that, a gradually decreases to zero. Then ( ) More than one answer 多选

A. The velocity changes more and more slowly
B. The velocity gradually decreases
C. The displacement keeps increasing
D. The displacement and velocity stay positive throughout

12. Zunyi No. 4 High School, Guizhou · 2016–17, Grade 10, first term Answer: _____
Which statement about acceleration is correct? ( )

A. If the acceleration keeps decreasing, the velocity must also keep decreasing
B. An object with a larger acceleration must have a larger change in velocity
C. If the direction of the acceleration stays the same, the direction of the velocity must also stay the same
D. Acceleration describes how quickly the velocity changes

13. Hengshui High School, Hebei · 2013–14, Grade 10, first term Answer: _____
A moving object's acceleration gradually decreases to zero. Its velocity could ( ) More than one answer 多选

A. keep decreasing
B. keep increasing
C. first decrease, then increase
D. first increase, then decrease

14. Hengshui High School, Hebei · 2013–14, Grade 10, first term Answer: _____
In straight-line motion, which of the following statements about acceleration and velocity are correct? ( ) More than one answer 多选

A. An object's acceleration keeps a constant direction, but the direction of its velocity may change
B. In uniformly decelerated linear motion, the acceleration must be negative
C. If an object's velocity is 0, its acceleration must also be 0
D. The acceleration in uniformly accelerated linear motion is positive only if the direction of the initial velocity is chosen as positive

Answers and explanations

1. C. A is wrong: the rate of change of velocity tells you how fast the velocity changes, not how much. B is wrong: Δv always points the same way as a. C is correct: if the velocity changes, $\Delta v \neq 0$, so $\Delta v / \Delta t \neq 0$. D is wrong: a is defined as $\Delta v / \Delta t$, but a does not depend on Δv or Δt (it depends only on the net force F and the mass m, which comes later), so there is no proportionality.
▶ **Watch 11:40, Example 1**

2. C. v_2 is shorter than v_1, so $\Delta v = v_2 - v_1$ points to the left. The acceleration points the same way as Δv, so it points to the left, opposite to v_1 (which points right). a and v are opposite, so the car is slowing down. That makes C correct; A, B and D are wrong.
▶ **Watch 18:01, Example 2**

3. ① F ② F ③ T ④ F ⑤ F ① F. $a = 0$ means the velocity does not change: the object is at rest or in uniform straight-line motion. ② F. Δv is large, but a also depends on the time. ③ T. Acceleration is the rate of change of velocity: the same thing. ④ F. A car moving right speeds up (a right), then brakes without stopping (a left): v keeps its direction, a does not. ⑤ F. Δv always points the same way as a, so a keeps its direction. But a is a vector: it is constant only if both magnitude and direction stay the same.
▶ **Watch 19:13, Example 3**

4. C. The sign of a shows only direction, so to compare magnitudes look at the numbers: $4 > 3$. Object 2 has the greater acceleration, so its velocity changes faster, and Object 1's changes more slowly (C is correct; D is wrong). A and B are wrong: we do not know the directions of their velocities.
▶ **Watch 21:32, Example 4**

5. B. Xiao Gang says: rising prices = speeding up. So the velocity is increasing. "Rising more slowly" means the velocity increases more and more slowly. So a and v point the same way, but a is decreasing.
▶ **Watch 26:19, Example 5**

6. A. Look only at the directions of a and v. Same direction: speeding up. Opposite: slowing down. A: v east, a west: opposite, slowing down. This can exist, and it does not matter that a grows. B: same direction would mean speeding up, not decreasing. C and D: opposite directions mean slowing down, not increasing.
▶ **Watch 27:48, Example 6**

7. D. A is wrong: $a = 0$ means at rest or uniform straight-line motion. B and C are wrong: knowing only that a decreases, you cannot tell whether v increases or decreases. D is correct: a describes how fast v changes, so the larger a is, the faster v changes.
▶ **Watch 31:41, Example 7**

8. B. The question asks for the incorrect statement. A is possible (opposite, slowing down). B is incorrect: zero acceleration means constant velocity, which need not be zero. C is possible: Object 1 changes by 10 m/s but $a = 10 / 1000 = 0.01\ m/s^2$; Object 2 changes by only 5 m/s but $a = 5 / 1 = 5\ m/s^2$. D is possible: a and v point the same way while a decreases, so the object keeps speeding up and v gets larger.
▶ **Watch 32:36, Example 8**

9. B. A is wrong: it can also move at constant velocity. B is correct: if a and v point the same way, v increases even while a decreases. C is wrong: if a and v are opposite, v decreases even while a increases. D: the second half is wrong. A rocket just after ignition has $v = 0$ yet a large acceleration.
▶ **Watch 34:19, Example 9**

10. B. Same direction: the object speeds up, more and more slowly. When a reaches 0 it keeps that velocity, which is the largest it has had. So B is correct and A is wrong. C: the object is still moving forward, so the displacement keeps increasing. D: the velocity never changes direction, so the object never turns around and the displacement keeps increasing.
▶ **Watch 35:53, Example 10**

11. A, C and D. Here "> 0" means pointing in the positive direction. a and v are both positive, so they point the same way: the object speeds up, then moves at constant velocity once a is 0. A is correct: a is getting smaller, so v changes more and more slowly. B is wrong: v does not decrease. C is correct: the object keeps moving in the positive direction. D is correct: s and v stay positive.
▶ **Watch 39:04, Example 11**

12. D. A is wrong: if a and v point the same way, v still increases while a decreases. B is wrong: the change in velocity also depends on the time. C is wrong: with a to the left and v to the right, the object slows down, stops, then moves left: the direction of v changes while a stays the same. D is correct: acceleration describes how quickly the velocity changes.
▶ **Watch 42:20, Example 12**

13. A, B and C. A is possible: a and v opposite, and a reaches 0 before v does. B is possible: a and v in the same direction. C is possible: opposite at first; v reaches 0 while a is not yet 0, then the object speeds up the other way. D is impossible: speeding up means a and v are in the same direction, and when a reaches 0 the velocity stays constant, so it never decreases.
▶ **Watch 43:31, Example 13**

14. A and D. A is correct: a and v opposite, two stages: slow down, then reverse. B is wrong: it depends on which direction you choose as positive. C is wrong: a rocket at the instant of ignition has v = 0 but a large a. D is correct: in uniform acceleration a and v point the same way, so a is positive only if v_0 is.
▶ **Watch 47:12, Example 14**

One-line summary

Look at the directions of a and v together: same direction means speeding up, opposite means slowing down, and it does not matter whether a gets bigger or smaller.

Key terms

Term	Meaning	Chinese
depends on	if A changes and B has to change with it, B depends on A	取决于 qǔjuéyú
change in velocity (Δv)	final velocity minus initial velocity	速度变化量 sùdù biànhuàliàng
speeding up / slowing down	speed increases / speed decreases	加速 / 减速 jiāsù / jiǎnsù
constant-acceleration linear motion	straight-line motion with constant acceleration	匀变速直线运动 yúnbiànsù zhíxiàn yùndòng
displacement	straight-line distance and direction from the start	位移 wèiyí