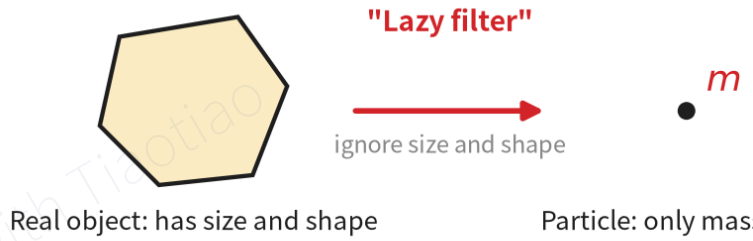
Particle (Point Mass)

Physics with Tiaotiao 跳跳 · Kinematics · High School Physics
Study sheet for the video "Point Mass (Particle) Explained": key ideas, practice questions, answers
Matches: NCERT Class 11 Ch 2 · FSc Part 1 Ch 3 · AS & A Level 9702 · WAEC/JAMB · HSC · AP Physics 1 Unit 1 · College Physics

Key ideas

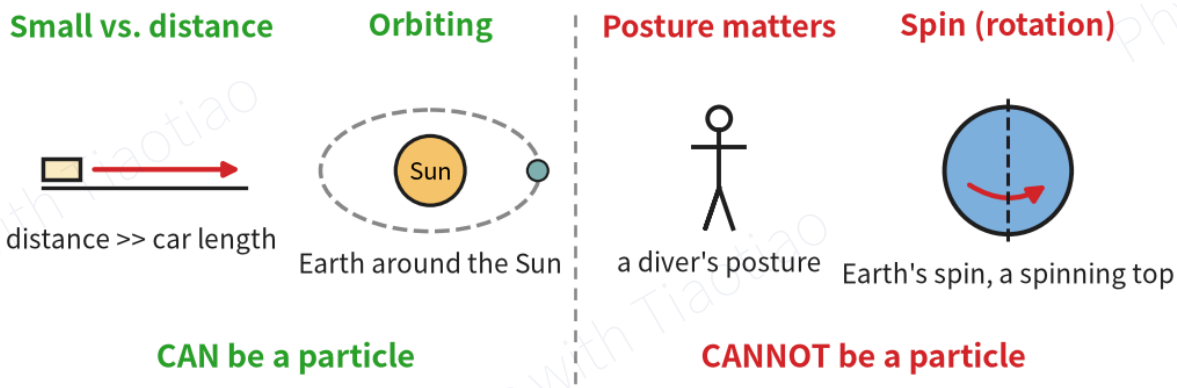
Particle: a point that has only **mass**; its shape and size are ignored (not a geometric point!)

Physical meaning: it simplifies the problem (being lazy). It is an **idealized model** and does not exist in reality.



The one condition: its shape and size have **no effect** (or little effect) on the problem being studied.
Whether something is a particle depends on the problem, not on the object.

Commonly tested



Can be treated as a particle	Cannot be treated as a particle
A vehicle much smaller than the distance it travels e.g. a 1 km long train travels 12,000 km: to find its average speed, treat it as a particle.	Its posture (body movements) matters e.g. can a bird land on a branch? A diver's posture.
Orbiting (revolution), when the body is small compared with its orbit	Studying its own spin (rotation) Exam tip: if its own rotation is involved, don't treat it as a particle.

Practice

Try these before checking the answers on the last page.

1. In physics, introducing the concept of the "particle" belongs to which scientific method? ( )

A. Observation and experiment

B. Building an idealized model

C. Analogy

D. Logical reasoning

Answer: _____ Why?

---

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

_____ (1) Any object with very small mass and very small volume can be treated as a particle.

_____ (2) If an object's shape and size have no effect, or little effect, on the problem being studied, it can be treated as a particle.

_____ (3) A particle has no size, so it is the same as a geometric point.

_____ (4) A particle is just a very small ball.

_____ (5) A particle is an idealized model that does not actually exist, so introducing this concept is not very meaningful.

3. (2021 Zhejiang gaokao) The four photos were taken with a high-speed camera. Which statement is correct? ( )

Gaokao is China's national college entrance exam.



Photo 1

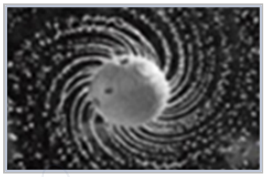


Photo 2



Photo 3



Photo 4

A. Studying the velocity of the cat walking on the floor (Photo 1), the cat can be treated as a particle

B. Studying why the water drops take their shape (Photo 2), the rotating ball can be treated as a particle

C. Studying whether the flying bird can land on the stump (Photo 3), the bird can be treated as a particle

D. Studying whether the rider and horse can clear the obstacle (Photo 4), the horse can be treated as a particle

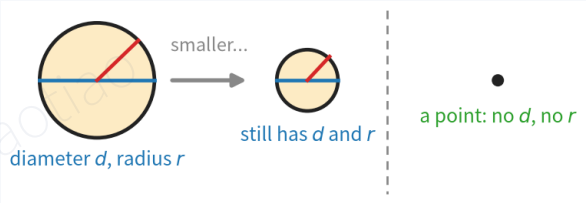
Answer: _____ Why are the others wrong?

Answers and explanations

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

1. **B**. A particle is an idealized model. If a question asks about the scientific method, particle = idealized model.
▶ **Watch 9:36, Example 1**

2. **(1) F (2) T (3) F (4) F (5) F**
(1) Small is not enough. Whether it can be a particle depends on the problem we study, not on the object. Example: an atom, when we study its rotation, is not a particle.
(3) A particle differs from a geometric point: it has mass.
(4) Even a tiny ball has a diameter and a radius. A point has neither.



(5) Exam tip: a statement that introducing a concept is meaningless is almost always false.
▶ **Watch 11:56, Example 2**

3. **A**. For the velocity of the walking cat, its shape and size don't matter, so it can be a particle.
B The ball is spinning: if its own spin is involved, it can't be a particle.
C Landing on a stump depends on the bird's posture.
D Clearing the obstacle depends on the horse's posture.
▶ **Watch 14:07, Example 3**

One-line summary

Shape and size don't matter for *this* problem → particle. Posture or spin matters → not a particle.

Key terms

Term	Meaning	Chinese
particle, point mass	an object treated as a point that has mass	质点 zhìdiǎn
idealized model	a simplified picture that keeps only what matters	理想模型 lǐxiǎng móxíng
mass	how much matter an object has	质量 zhìliàng
orbiting, revolution	moving around another body, e.g. Earth around the Sun	公转 gōngzhuàn
spin, rotation	turning around its own axis	自转 zìzhuàn
scientific method	a way of doing science, e.g. building models, experiments	科学方法 kēxué fāngfǎ

Frame of Reference & Coordinate System

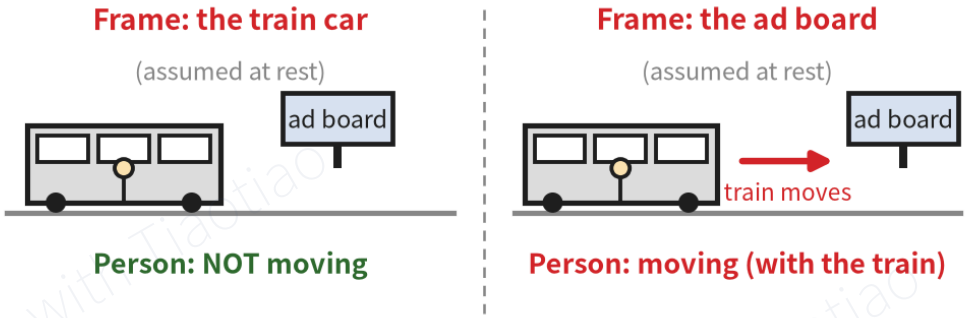
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Study sheet for the video "Frame of Reference & Coordinate System": key ideas, practice questions, answers

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 · AP Physics 1 Unit 1 · College Physics

Key ideas

Why we need a frame: without a **reference frame**, no kinematics problem can be studied. Whether you move depends not on you, but on the frame you choose.



Reference frame: an object (or system) chosen for studying motion and **assumed to be at rest**.
Physical meaning: to decide, in the problem you are studying, whether an object is moving or at rest.

Three key points

1. A frame is **not truly at rest**. It is only assumed to be at rest.
2. It can be **chosen freely**. In high school the default is the ground.
3. With a **different frame**, an object's state of motion is different.

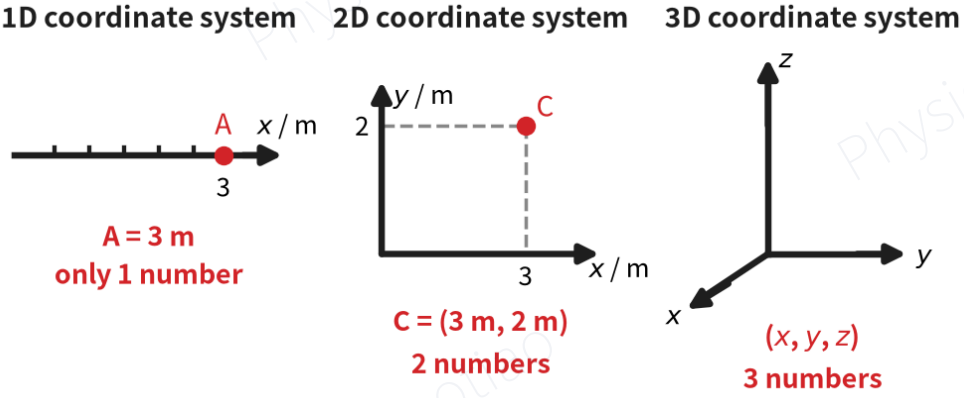
A "reference frame" is the same as the "reference object" from middle school.

Exam trick: to find which object is the frame, **see which one is not moving**. Find the verb, find its subject: whoever moves is not the frame, whoever doesn't move is.

Choosing a frame: pick the one that simplifies the problem. Example: with the Sun at the center (heliocentrism) the planets move in simple circles. With the Earth at the center (geocentrism) their paths are very complicated.

Coordinate system: also a reference frame, but one with a ruler, so it can give an object's position. In 1D (a straight line), **one number** is enough. A 2D system needs two numbers, a 3D system three.

Coordinates in physics must include **units**!



Practice

Try these before checking the answers on the next page.

1. An ancient poet once wrote: "Empty-handed, I hold a hoe; on foot, I ride a water buffalo. I walk on the bridge: the bridge flows, the water doesn't." In "the bridge flows, the water doesn't," "the bridge flows" should be understood as choosing which object as the reference frame? ( )

(The poet's wording: walking on the bridge, he sees the bridge seem to flow and the water stand still.)

A. Water B. Bridge C. Person D. Ground

Answer: _____ Which word is the verb, and who is its subject?

---

2. Which of the following statements are correct? ( )

A. "The Sun rises in the east" uses Earth as the reference frame

B. "The Moon glides through the clouds" uses the clouds as the reference frame

C. "The little raft drifts down the river, the towering green mountains move past on both banks" use the same reference frame

D. The reference frame must be an object at rest relative to the ground

Answer: _____ Why are the others wrong?

---

3. A ball falls from 5 m above the ground, bounces off the ground, and is caught 1 m above the ground. The origin is set 2 m directly below the release point, and downward is the positive direction of the axis. What are the position coordinates of the release point, the landing point, and the catch point, respectively? ( )

A. −2 m, 3 m, 2 m

B. −2 m, 2 m, 1 m

C. −2 m, −2 m, −1 m

D. 4 m, 0, 1 m

Answer: _____ Draw the axis here, or show your working:

Answers and explanations

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

1. **A**. "Flows" has the bridge as its subject, so the bridge is moving. "Doesn't flow" has water as its subject, so the water is not moving. The one that is not moving is the frame: water.

Check: with the ground as the frame we would see the bridge still and the water flowing, the opposite of the poem. So the frame is not the ground.

▶ **Watch 9:29, Example 1**

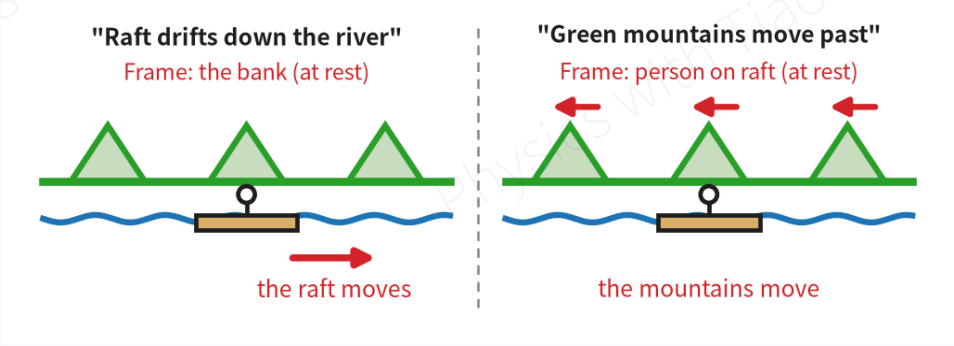
2. **A and B are correct. C and D are wrong.**

A. "Rises": the subject is the Sun, so the Sun moves. The mountain it rises from does not move. It is a mountain on Earth, so the frame is Earth.

B. "Glides through": the subject is the Moon, so the Moon moves. Only the clouds are left, so the frame is the clouds.

C. Wrong. First line: the raft moves, so the bank is at rest and is the frame. Second line: the mountains move relative to the people on the raft, like poles moving past a bus window. So the frame is the person on the raft. The two frames are different.

D. Wrong. A frame can be chosen freely. It can be moving or not.

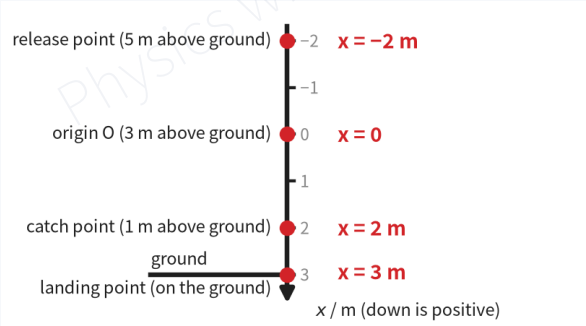


▶ **Watch 10:24, Example 2**

3. **A**. Downward is positive, so points above the origin O are negative and points below it are positive.

Release point: 2 m above O, so **−2 m**. Landing point: the ground is 5 − 2 = 3 m below O, so **3 m**. Catch point: 1 m above the ground, so 3 − 1 = 2 m below O, which gives **2 m**.

Remember the units: coordinates in physics always need them.



▶ **Watch 18:55, Example 3**

One-line summary

To find the frame, see who is not moving. A coordinate system is a frame with a ruler, and its coordinates need units.

Key terms

Term	Meaning	Chinese
reference frame, frame of reference	an object chosen to study motion and assumed to be at rest	参考系 cānkǎoxì
coordinate system	a reference frame with a ruler, used to give positions	坐标系 zuòbiāoxì
origin	the point where the coordinate is zero	原点 yuándiǎn
positive direction	the direction in which coordinates are positive	正方向 zhèngfāngxiàng
at rest	not moving relative to the frame	静止 jìngzhǐ
heliocentrism	the Sun at the center	日心说 rìxīnshuō
geocentrism	the Earth at the center	地心说 dìxīnshuō
1D, 2D, 3D	one, two or three number(s) are needed for a position	一维、二维、三维 yīwéi, èrwéi, sānwéi

Instant vs Time Interval

Physics with Tiaotiao 跳跳 · Kinematics · High School Physics

Study sheet for the video "Instant vs Time Interval": key ideas, practice questions, answers

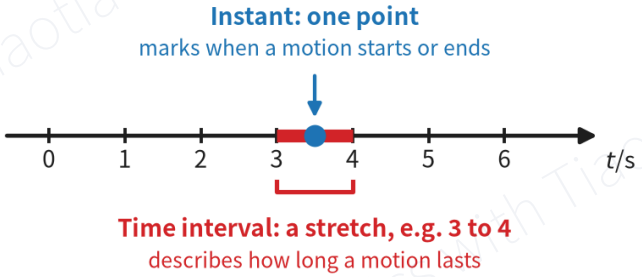
Matches: NCERT Class 11 Ch 2 · FSc Part 1 Ch 3 · AS & A Level 9702 · WAEC/JAMB · HSC · College Physics

Key ideas

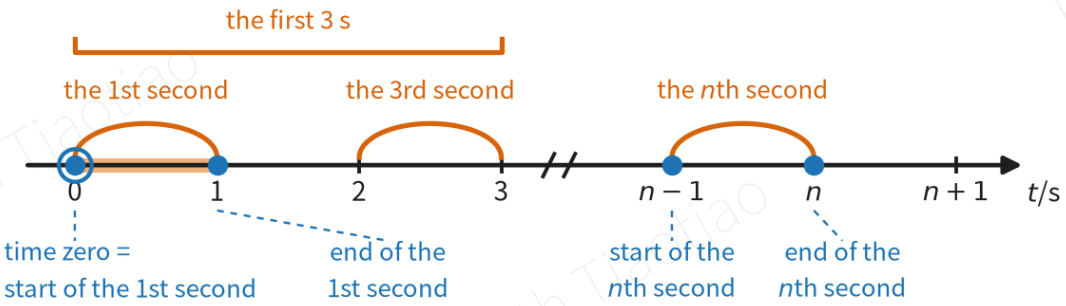
In daily life, "time" means two things: a point in time (5:00, 3 a.m.) or a stretch of time (2 days, half an hour). Physics gives them two different names.

Instant: a single point in time, **one point** on the time axis. It marks when a motion starts or ends.
A photo records what happened at one instant.

Time interval: a stretch of time, **one segment** of the time axis. It describes how long a motion lasts.
1 s, 1 h, 1 day, three days and three nights: all time intervals.

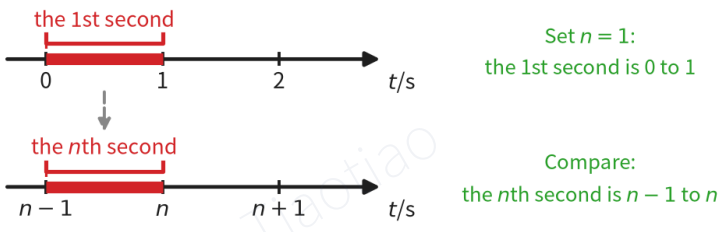


Commonly tested



There is no "0th second". The time axis starts at 0, so the very first stretch, 0 to 1, is the 1st second. But there *is* a time zero (an instant).

Trick for "*n*th" questions: if you get stuck, **set *n* = 1**. The 1st second is 0 to 1, so the *n*th second is *n*−1 to *n*.



Practice

Try these before checking the answers on the last page.

1. Warm-up. A pupil wrote a diary letter to his dad. Is each phrase an instant (I) or a time interval (T)?

_____ (1) "it should already be 5:00"
_____ (2) "for the last 2 days"
_____ (3) "from 7:00 in the morning to 12:00 at night"
_____ (4) "more than ten hours straight"
_____ (5) "startled me awake at 3 a.m."
_____ (6) "took half an hour to fall asleep again"
_____ (7) "I slept for forty minutes in math class"

2. Which of the following timing data refers to a time interval? ( )

A typical Grade 10 exam question in China.

A. CCTV's news broadcast lasts 30 min

B. The Hong Kong handover took effect at 0:00 on 1 July 1997

C. The Beijing Olympics opening ceremony began at 8 p.m. on 8 August 2008

D. At 21:16:03 on 29 September 2011, Tiangong-1 was launched from the Jiuquan Satellite Launch Center

Answer: _____ Why?

---

3. Fill in. Time intervals or instants?

(1) the 3rd second: _____ (2) the first 3 s: _____ (3) the end of the 1st second: _____

(4) time zero: _____ (5) the start of the *n*th second: _____

(6) The *n*th second runs from _____ to _____ .

4. For the time axis shown, which statement about instants and time intervals is correct? ( )



A. t_2 is an instant, called the end of the 2nd second or the start of the 3rd second, and can also be called "within 2 s"

B. t_2 to t_3 is a time interval, called the 3rd second

C. t_0 to t_2 is a time interval, called the first 2 s or the 2nd second

D. t_{n-1} to t_n is a time interval, called the (n−1)th second

Answer: _____ Why are the others wrong?

Answers and explanations

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

1. **(1) I** **(2) T** **(3) T** **(4) T** **(5) I** **(6) T** **(7) T**
Points in time: 5:00 and 3 a.m. Stretches of time: 2 days, 7:00 to 12:00, over ten hours, half an hour, forty minutes.
▶ **Watch 2:35, Warm-up**

2. **A**. A runs from 7:00 to 7:30 p.m., so it is a time interval.
B 0:00 on 1 July is one instant, not a stretch of time.
C The ceremony began right after 8 p.m. Read C as 8:00:00 p.m.: an instant.
D The launch happened at that one instant, even though the time is given to the second.
▶ **Watch 5:29, Example 1**

3. (1) **interval** (2) **interval** (3) **instant** (4) **instant** (5) **instant** (6) ***n*−1 to *n***
Set $n = 1$ to check (6): the 1st second is 0 to 1, so the nth second is $n-1$ to n.
▶ **Watch 7:15, Phrases**

4. **B**. t_2 to t_3 is a stretch, so it is a time interval. Counting from 0: 0 to 1 is the 1st second, 1 to 2 the 2nd, 2 to 3 the 3rd.
A t_2 is a point, so it is an instant. "End of the 2nd second or start of the 3rd" is right, but "within 2 s" is a stretch. A point can't also be a time interval.
C 0 to t_2 is "the first 2 s", but not "the 2nd second". The 2nd second is only 1 to 2.
D Set $n = 1$: t_{n-1} to t_n becomes t_0 to t_1, which the option calls the "0th second". There is no 0th second. Change $n-1$ to n and D is right.
▶ **Watch 10:31, Example 2**

One-line summary

An instant is a point; a time interval is a stretch. The nth second is $n-1$ to n (stuck? set $n = 1$), and there is no 0th second.

Key terms

Term	Meaning	Chinese
instant	one point on the time axis	时刻 shíkè
time interval	a stretch (segment) of the time axis	时间（间隔） shíjiān (jiàngé)
time axis	a line that shows time t in seconds	时间轴 shíjiānzhóu
time zero	the instant $t = 0$, the start of the 1st second	零时刻 líng shíkè
the nth second	the stretch from $n-1$ to n	第 n 秒 dì n miǎo
the first 3 s	the stretch from 0 to 3	前 3 秒 qián sān miǎo
the end of the 1st second	the instant $t = 1$ s	第 1 秒末 dì yī miǎo mò

Vectors vs Scalars

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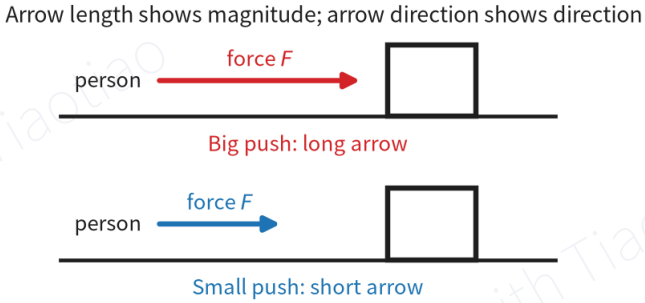
Study sheet for the video "Scalars vs Vectors Explained": key ideas, practice questions, answers

Matches: NCERT Class 11 Ch 3 Motion in a Plane (scalars and vectors) · FSc Part 1 Ch 2 Vectors and Equilibrium · AS & A Level 9702 · WAEC/JAMB · HSC · College Physics · AP Physics 1 Unit 1

Key ideas

Vector: a physical quantity with both **magnitude** and **direction**. It is drawn as an **arrow**: the length shows the magnitude, the arrow's direction shows the direction. Examples: velocity, force.

Scalar: a physical quantity with **magnitude only**. It is written as a **number**. Examples: mass, volume, temperature.



Simple notation for 1D vectors (vector algebraization): a vector with only two directions is a **1D vector**. Pick one direction as **positive** (right, say). Then a vector is just **a number with a sign**. Example: the displacement from O to A points right and is 3 m long, so $\mathbf{x_{OA} = +3\ m}$. Forces and velocities are written the same way: +5 N, −2 N, +5 m/s, −3 m/s.

Only 1D vectors can be written like this. A 2D vector has endless directions, and + and − are not enough.

Comparing vectors: ignore the sign, look only at the numbers. 10 N is bigger than 3 N.

Real and fake directions: a **real direction** is a direction in space: you can say east, west, south or north. A **fake direction** is not a direction in space: you can't say east, west, south or north (e.g. "aiming for a score of 90"). Only vectors have real directions. Some scalars have a direction, but it is always fake.

Quick test: say "it points 37.5° south of east". Sounds odd? Fake direction, so a scalar (current). Sounds fine? Real direction, so a vector (velocity).

Three uses of the + and − signs

Use	Example
1. Positive and negative numbers (order of size)	−3 is smaller than +2
2. The direction of a 1D vector: + same as the positive direction, − opposite	F_1 = +3 N, F_2 = −10 N
3. The two values of a property	A battery's poles: positive pole, negative pole

+ and − are just an ordinary pair of symbols. They need not show size, and not only vectors have them.

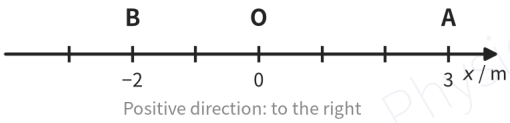
Practice

1. Write V (vector) or S (scalar) for each quantity.

_____ (1) velocity _____ (2) force _____ (3) mass

_____ (4) volume _____ (5) temperature _____ (6) displacement

2. On the axis below, O is the origin, A is at 3 m and B is at −2 m. Take the positive direction to the right.



Positive direction: to the right

(a) Write the displacement from O to A and from O to B as signed numbers.

(b) Can a 2D vector be written as one signed number? Why or why not?

3. Decide whether each direction is real (R), fake (F) or there is no direction (N).

_____ (1) the direction of velocity _____ (2) the direction of current

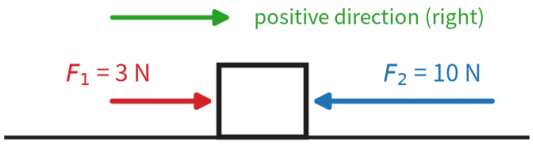
_____ (3) mass _____ (4) "I'm aiming for a score of 90"

Current flows from the positive to the negative pole, so why is it a scalar?

4. Which use of the + and − signs is each case? Write 1, 2 or 3 (see "Three uses" on page 1).

_____ (a) the poles of a battery, + and − _____ (b) F_2 = −10 N _____ (c) −3 is smaller than +2

5. Qi Xiaoyu pushes a box to the right with F_1 = 3 N, then to the left with F_2 = 10 N. Take right as positive.



Qi Xiaoyu pushes right (F_1), then left (F_2)

(a) Write F_1 and F_2 as signed numbers. _____ _____

(b) Which force is bigger? Why?

6. True (T) or false (F)?

_____ (1) Only vectors can have + or − signs.

_____ (2) A + or − sign always shows the size of a quantity.

_____ (3) Some scalars have a direction, but it is always a fake direction.

_____ (4) A scalar can have a real direction.

_____ (5) Any vector, 1D or 2D, can be written as one signed number.

_____ (6) −10 N is a bigger force than +3 N.

Answers and explanations

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

1. **(1) V** **(2) V** **(3) S** **(4) S** **(5) S** **(6) V**
Velocity, force and displacement have both magnitude and direction, so they are vectors. Mass, volume and temperature have magnitude only, so they are scalars.
▶ **Watch 1:03, Example 1**

2. (a) x_{OA} = **+3 m**; x_{OB} = **−2 m**.
O to A points right (positive) and is 3 m long, so +3 m. O to B points left (negative) and is 2 m long, so −2 m.
(b) No. A 2D vector has endless directions, and + and − can only show two. Only 1D vectors can be written as a signed number.
▶ **Watch 3:26, Example 2**

3. **(1) R** **(2) F** **(3) N** **(4) F**
Velocity: "37.5° south of east" sounds fine, so the direction is real. Current: it sounds odd, so the direction is fake. Mass has no direction at all. A score of 90 is called a direction, but you can't say east, west, south or north.
Current: its direction is fake (positive to negative pole, not a direction in space). A scalar can have a fake direction. Only vectors have real directions, so current is a scalar.
▶ **Watch 7:07, Example 3**

4. **(a) 3** **(b) 2** **(c) 1**
(a) The poles of a battery are just two names, + and −: two values of one property. (b) The sign shows direction: opposite to the positive direction. (c) The sign shows order of size.
▶ **Watch 9:36, Example 4**

5. (a) $\mathbf{F_1}$ **= +3 N** (same direction as +), $\mathbf{F_2}$ **= −10 N** (opposite to +).
(b) F_2 is bigger. When comparing vectors, ignore the sign and compare the numbers: 10 N > 3 N.
▶ **Watch 10:05, Example 5**

6. **(1) F** **(2) F** **(3) T** **(4) F** **(5) F** **(6) T**
(1) A battery's poles and temperatures have signs too, and they are not vectors. (2) A sign need not show size, e.g. a battery's poles. (4) A scalar's direction is always fake. (5) Only 1D vectors. (6) Compare the numbers: 10 N is more than 3 N.
▶ **Watch 12:33, Example 6**

One-line summary

Vector: arrow, real direction. Scalar: a number. A 1D vector is a signed number, and when you compare sizes you ignore the sign.

Key terms

Term	Meaning	Chinese
vector	has magnitude and a real direction	矢量 shǐliàng
scalar	has magnitude only, written as a number	标量 biāoliàng
1D vector	a vector with only two directions	一维矢量 yīwéi shǐliàng
vector algebraization	writing a 1D vector as a signed number	矢量代数化 shǐliàng dàishùhuà
positive direction	the direction we choose to call +	正方向 zhèngfāngxiàng
real / fake direction	a direction you can / can't call east, west, south or north	真方向 / 假方向 zhēn fāngxiàng / jiǎ fāngxiàng
displacement	a vector from the start to the end	位移 wèiyí
current	flow of electric charge (a scalar)	电流 diànliú

Distance vs Displacement

Physics with Tiaotiao 跳跳 · Kinematics · High School Physics

Study sheet for the video "Distance vs Displacement": key ideas, practice questions, answers

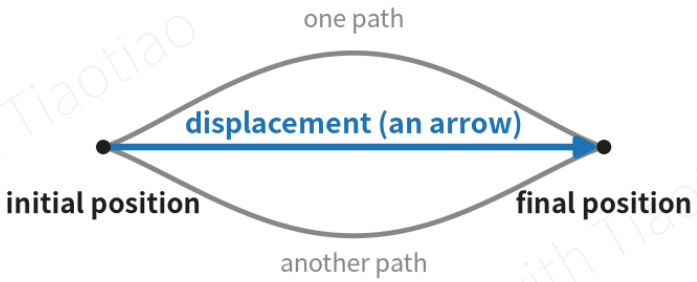
Matches: NCERT Class 11 Ch 2 · FSc Part 1 Ch 3 · AS & A Level 9702 · WAEC/JAMB · HSC · AP Physics 1 Unit 1 · College Physics

Key ideas

1. Definitions.

Displacement describes the *change in position*. It is a vector: an arrow from the initial position to the final position. Its length is the straight-line distance between the two positions. It does not depend on the path.

Distance is the length of the path actually travelled. It is a scalar (just a number), and it depends on the motion.



Example: run one lap of a 400 m track and come back to the start. Displacement $x = 0$. Distance $s = 400$ m.

2. Writing 1D displacement: a sign plus a number. The sign gives the direction; the number gives the magnitude.

Axis: B at −2, O at 0, A at 3 (right is positive)	Value
O to A: to the right, same as positive	$x_{OA} = +3$ m (the + may be left out)
O to B: to the left, opposite to positive	$x_{OB} = -2$ m
A to B (from 3 to −2): to the left, 5 units	$x_{AB} = -5$ m

3. Displacement from coordinates: displacement = final coordinate − initial coordinate. Never subtract the other way round.

0 to 1: +1 m = 1 − 0 · −2 to 2: +4 m = 2 − (−2) · 3 to −2: −5 m = −2 − 3

Careful: the + or − in a coordinate such as −1 or 3 only tells which side of the origin the point is on. It is not a math sign. Treating it as a math sign in the subtraction just happens to give the displacement.

4. Comparing distance and displacement. You **cannot** compare distance with displacement: one is a number, the other is an arrow. You can compare distance with the **magnitude** of the displacement:

distance ⩾ magnitude of displacement

Equality holds **only in one-way straight-line motion**. If the object turns back, even on a straight line, distance > magnitude of displacement.

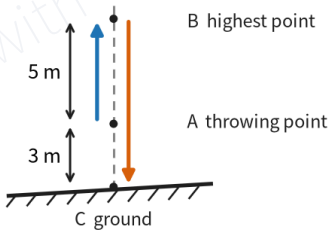
Practice

Try these before checking the answers on the next page.

1. As shown, a ball is thrown straight up from point A, 3 m above the ground. It rises 5 m, then falls back and finally reaches the ground at point C. What is the magnitude of the ball's displacement from A to C? ( )

A. 3 m B. 5 m C. 8 m D. 16 m

Answer: _____ Why?



2. A particle moves back and forth along a straight line, as shown. OA = AB = OC = CD = 1 m, O is the origin of the x-axis, and the direction shown is positive. The particle starts at A, moves in the positive x direction to B, then returns in the negative x direction. Which statements are correct? ( ) (Select all that apply.)



A. From A→B→C, the displacement is 2 m and the distance is 4 m

B. From B→D, the displacement is −4 m and the distance is 4 m

C. When the particle reaches D, its position can be written as D's coordinate, −2 m

D. When the particle reaches D, its displacement relative to A is −3 m

Answer: _____ _____ Working:

3. A person runs 1¾ laps around a horizontal circle of radius R. His ( )

A. Distance and magnitude of displacement are both 3.5πR

B. Distance is 3.5πR; magnitude of displacement is $\sqrt{2}$R

C. Distance and magnitude of displacement are both R

D. Distance is 0.5πR; magnitude of displacement is $\sqrt{2}$R

Answer: _____ Working:

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

_____ (1) In straight-line motion, the magnitude of the displacement equals the distance.

_____ (2) In one-way straight-line motion, an object's distance equals its displacement.

_____ (3) If an object's displacement is zero, its distance is not necessarily zero.

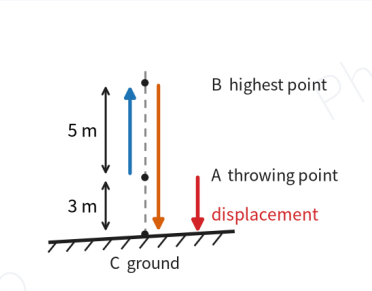
_____ (4) The greater a moving object's distance, the greater its displacement.

_____ (5) The "25 km" on an expressway sign means the displacement from here to the next exit is 25 km.

Answers and explanations

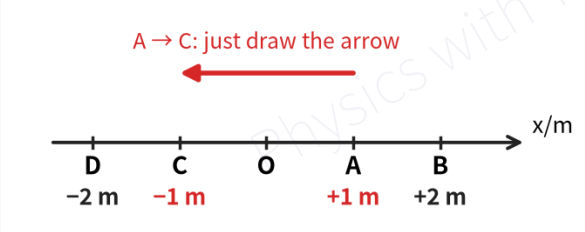
Tap a blue time to jump to the part of the video that explains the question.

1. A. Displacement only looks at the change in position from start to end, not at the motion in between. A and C are 3 m apart on a vertical line, so the magnitude is 3 m, pointing down from A to C.
For comparison, the distance is 5 + 5 + 3 = 13 m: the whole path added up.



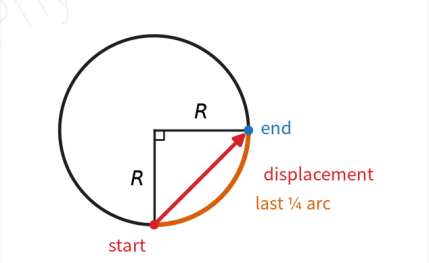
▶ **Watch 13:14, Example 1**

2. B, C, D are correct; **A** is wrong.
Coordinates: $x_A = 1$ m, $x_B = 2$ m, $x_C = -1$ m, $x_D = -2$ m. Use final − initial.



A From A to C the displacement is −1 − 1 = −2 m, not 2 m: the sign is missing. (The distance 1 + 3 = 4 m is right, but the statement is still wrong.)
B $x_D - x_B = -2 - 2 = -4$ m. B to D is all to the left, so the distance is 4 m.
C On a 1D axis one number gives a position. At D the coordinate is −2 m: the sign says which side of O, the number says how far from O.
D $x_D - x_A = -2 - 1 = -3$ m.
Tip: never drop the sign of a displacement. "Final minus initial" will not lose it.
▶ **Watch 14:05, Example 2**

3. B. Distance is the length of the path: 1¾ = 7/4 laps, each lap is 2πR, so $s = 7/4 \times 2\pi R = 3.5\pi R$.



Displacement magnitude is the straight line from start to end. After 1 full lap and ¾ of a lap, exactly a quarter arc is left, so start, centre and end make a right angle. The two radii R are the short sides, and the displacement is the hypotenuse: $\sqrt{(R^2 + R^2)} = \sqrt{2}\,R$.
▶ **Watch 16:18, Example 3**

4. **(1) F** **(2) F** **(3) T** **(4) F** **(5) F**
(1) "One-way" is missing. With turn-backs, distance is greater than the magnitude of displacement.
(2) Distance is a number and displacement is an arrow, so they cannot be equal. It should say "distance equals the *magnitude* of the displacement". Exam tip: compare distance only with the magnitude.
(3) True. Run one lap and come back: displacement is 0, distance is not.
(4) Run one lap, or a bigger lap: distance grows, displacement is still 0.
(5) The 25 km is the length of the road you drive (it may have curves), not the straight line to the exit. It is a distance.
▶ Watch 17:39, Example 4

One-line summary

Displacement is an arrow (final − initial); distance is a number. Compare distance only with the magnitude of displacement: it is never smaller, and equal only for one-way straight-line motion.

Key terms

Term	Meaning	Chinese
displacement	a vector arrow from the initial to the final position	位移 wèiyí
distance	the length of the path actually travelled (a scalar)	路程 lùchéng
initial / final position	where the motion starts / ends	初位置 / 末位置 chūwèizhì / mòwèizhì
magnitude	the size of a vector, without direction	大小 dàxiǎo
coordinate	the number that gives a position on an axis	坐标 zuòbiāo
one-way straight-line motion	straight-line motion with no turning back	单向直线运动 dānxiàng zhíxiàn yùndòng

Average Speed vs Average Velocity vs Instantaneous Velocity

Physics with Tiaotiao 跳跳 · Kinematics · High School Physics

Study sheet for the video "Average Speed vs Average Velocity vs Instantaneous Velocity": 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

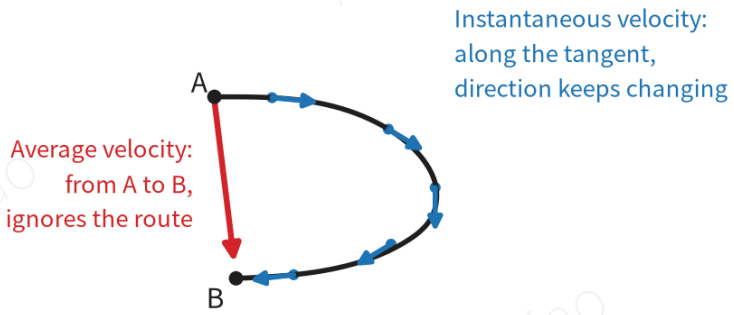
"Fast" has two meanings. Middle school "speed" = how fast you **cover ground** (distance ÷ time). High school adds a second meaning: how fast you **get there** (displacement ÷ time).

Average velocity: displacement ÷ time, v = x / t, unit m/s. It is a **vector**; its direction is the direction of the displacement. Its magnitude is the straight-line distance from start to end, divided by time.
Ignore the process, only the result (start and end) matters. It is about a time interval, not an instant. Always give the direction.

Average speed: distance ÷ time, unit m/s. It is a **scalar** (magnitude only). **Average speed is NOT the magnitude of average velocity!**

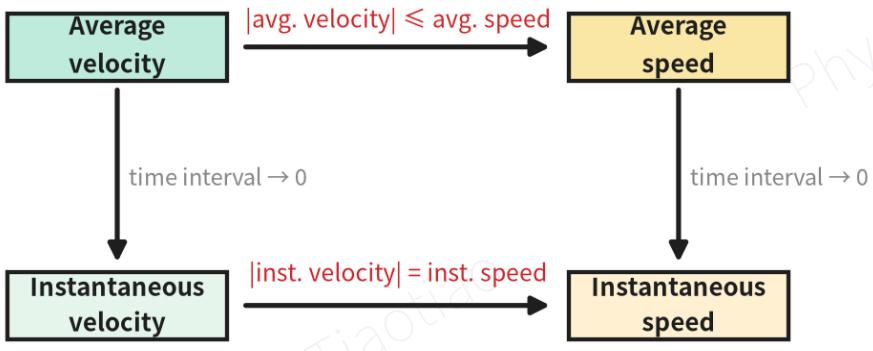
Instantaneous velocity: how fast and in which direction an object moves at one instant (one position). It is the average velocity over an **extremely short time** (e.g. 0.0001 s). A vector; its direction is the **tangent** to the path (a car driving normally: the way it points).

Instantaneous speed = the magnitude of instantaneous velocity. A scalar.



Uniform linear motion = motion with constant instantaneous velocity (constant direction, so a straight line; constant magnitude, so a steady rate). Its average velocity does not depend on which time interval you pick.

Commonly tested



Rule	Notes
Average speed ⩾ magnitude of average velocity	The straight line is the shortest path, so distance ⩾ displacement. Equal only for **one-way straight-line motion**.
Average velocity is 0, average speed is not 0	Back at the start (a full lap): displacement is 0 but distance is not.
Average or instantaneous?	Look at the time. **Extremely short** time (an instant, a position) = instantaneous. A longer time = average. Over a very short time, any motion can be treated as uniform linear motion.
Velocity and speed	They cannot be compared in size (a vector is an arrow, a scalar is a number). The *magnitude* of velocity can be compared with speed.
A problem just says "velocity"	Exam convention: read it as instantaneous velocity. But if the problem gives a time interval or a displacement, still check whether it is average or instantaneous. The textbook also notes that in daily life "velocity" sometimes means speed: judge from context.
Which word to look for	For average velocity, look at **displacement**. For average speed, look at **distance**.

Practice

Try these before checking the answers on the last pages. Goutiao is the dog and Goumao is the cat.

1. Two taxi trips, both from home to Peking University. Trip 1: 7.5 km in 14 min. Trip 2: 10 km in 15 min. (a) Which trip gets there sooner? (b) Work out distance ÷ time for each trip. Which trip covers more ground per minute?

(a) _____ (b) Trip 1: _____ km/min Trip 2: _____ km/min

2. Goutiao, our pet dog, ran 10 laps around the neighborhood, 200 m per lap, in 20 min. What is the average velocity?

Answer: _____

3. Goumao, our pet cat, dashed around the house: first 2 m to the right, then 6 m to the left, 20 s in total. What is the average velocity?

Answer: _____ m/s, direction: _____

4. Which statement about average velocity has the correct physical meaning? ( )

A. A car's average velocity at the end of 10 s after setting off is 5 m/s

B. A car's average velocity over some time interval is 5 m/s, meaning its displacement in every 1 s of that interval is 5 m

C. Average velocity only roughly reflects how fast an object moves

D. To find average velocity, you must take into account how the velocity changes during that interval

Answer: _____

5. Goumao (the cat) runs around at home: 2 m to the right, then 6 m to the left, 20 s in total. What are its average velocity and average speed?

Average velocity: _____ Average speed: _____

6. Goutiao (the dog) chases Goumao from behind, running 10 m to the right in 5 s. What are its average velocity and average speed?

Average velocity: _____ Average speed: _____

7. After an earthquake, roads and bridges were wrecked and vehicles could not get through. To reach the disaster area quickly, a rescue team crossed obstacle after obstacle on foot, covering 60 km of rugged mountain road in 5 h. Which statement about the rescuers' velocity and speed is correct? ( )

A. The average velocity is 3.3 m/s

B. The velocity at every instant is 3.3 m/s

C. The average speed is 3.3 m/s

D. The speed at every instant is 3.3 m/s

Answer: _____ Why?

_____

8. True or false? Uniform linear motion is exactly motion with constant instantaneous velocity. _____

9. Which of the velocities below are average velocities, and which are instantaneous velocities? Write "average" or "instantaneous".

_____ (1) A sprinter in the 100 m race crosses the finish line at 9.5 m/s;

_____ (2) After the speed-up, the train reaches 150 km/h;

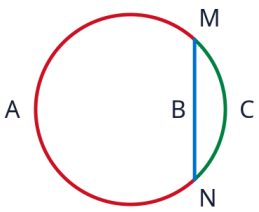
_____ (3) Because of a traffic jam, the car moves through the tunnel at only 1.2 m/s;

_____ (4) A space capsule returning to Earth lands in the Pacific Ocean at 8 m/s;

_____ (5) A bullet hits a wall at 800 m/s.

10. At a school sports meet, Teacher Liu runs one lap around a 400 m circular track and returns to the start in 80 s. Over this time, his average velocity is _____ m/s and his average speed is _____ m/s. As he crosses the finish line, the magnitude of his velocity is _____ his speed at that instant (fill in >, < or =).

11. The figure shows the paths of three particles A, B and C. All three start from N at the same time and reach M at the same time. Which of the following statements is correct? ( )



A. From N to M, A has the greatest average velocity.

B. From N to M, the three particles have the same average speed.

C. From N to M, A has the greatest average speed.

D. On reaching M, A has the greatest instantaneous speed.

Answer: _____

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

_____ (1) Instantaneous velocity is just the average velocity of a moving object over a short time interval.

_____ (2) For uniform linear motion, the average velocity does not depend on which time interval (or which displacement) you pick.

_____ (3) Instantaneous speed is the magnitude of instantaneous velocity.

_____ (4) Average speed is the magnitude of average velocity.

_____ (5) If the average velocity of a motion is zero, its average speed is also zero.

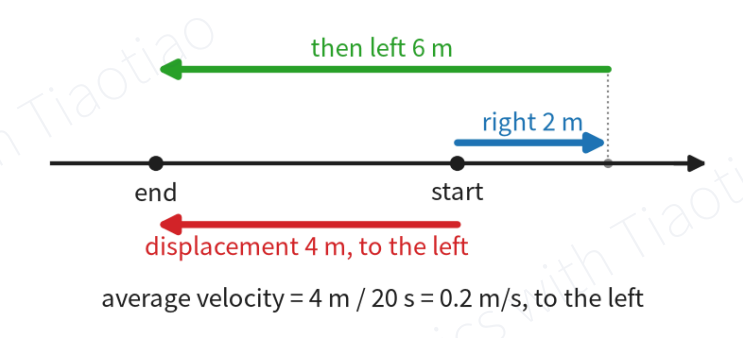
Answers and explanations

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

1. (a) **Trip 1** gets there sooner: same start and end, less time. (b) Trip 1: 7.5 ÷ 14 ≈ **0.54 km/min**. Trip 2: 10 ÷ 15 ≈ **0.67 km/min**. Trip 2 covers more ground per minute, so Trip 2 "runs faster".
"Gets there fast" = average velocity (displacement ÷ time). "Runs fast" = average speed (distance ÷ time).
▶ **Watch 1:46, Example 1**

2. **0**. After ten full laps the dog is back at the start, so its position has not changed: displacement = 0, and average velocity = 0 ÷ 20 min = 0. The 2000 m is distance, so it is not used.
▶ **Watch 5:45, Example 2**

3. **0.2 m/s, to the left**. Taking right as positive, the cat ends 6 − 2 = 4 m to the left of the start, so the displacement is 4 m to the left. Average velocity = 4 m ÷ 20 s = 0.2 m/s, in the direction of the displacement: to the left.



▶ **Watch 5:45, Example 3**

4. **C**. Average velocity only records the result, so it only roughly reflects how fast an object moves.
A 10 s after setting off is an instant. An average velocity needs a time interval. **B** The same 25 m in 5 s can be 5 m every second, or standing still for 4 s and then 25 m in the 5th second. The average velocity is 5 m/s both times, so it cannot show the process. **D** Average velocity = displacement ÷ time. You do not need to know how the velocity changes.
▶ **Watch 7:41, Example 4**

5. **Average velocity 0.2 m/s to the left; average speed 0.4 m/s.** Average speed = distance ÷ time = (2 + 6) m ÷ 20 s = 8 m ÷ 20 s = 0.4 m/s. The two are not equal.
▶ **Watch 10:59, Example 5**

6. **Average velocity 2 m/s to the right; average speed 2 m/s.** Displacement = 10 m to the right, so v = 10 m ÷ 5 s = 2 m/s, to the right. Distance is also 10 m, so average speed = 10 m ÷ 5 s = 2 m/s.
In one-way straight-line motion, the magnitude of average velocity = average speed.
▶ **Watch 11:48, Example 6**

7. **C**. The 60 km follows a winding mountain road, so it is distance, not displacement. Distance ÷ time is average speed: 60 000 m ÷ (5 × 3600 s) ≈ 3.3 m/s. **A, B** use "velocity", which needs displacement. **D** The problem gives only the total distance and total time, so we cannot say the speed is 3.3 m/s at every instant.
▶ **Watch 12:57, Example 7**

8. **True**. Constant direction means it can only move in a straight line. Constant magnitude means it moves at a steady rate. Together, that is uniform linear motion.
▶ **Watch 18:43, Example 8**

9. (1) **instantaneous**; (2) **average**; (3) **average**; (4) **instantaneous**; (5) **instantaneous**.
Look at the time: an extremely short time (a moment, a position, e.g. 0.0001 s) means instantaneous.
For (2), this is the standard answer for this problem, not a general rule: one instant says nothing about arriving sooner. What counts is the overall speed after the speed-up.
▶ **Watch 18:54, Example 9**

10. **0 m/s; 5 m/s; =**. He ends where he started, so the displacement is 0 and the average velocity is 0. The distance is 400 m, so the average speed is 400 m ÷ 80 s = 5 m/s. At the finish line the time is extremely short, so we mean instantaneous: the magnitude of instantaneous velocity equals instantaneous speed.
▶ **Watch 24:28, Example 10**

11. **C**. All three have the same displacement (N to M) and the same time, so they have the same average velocity: **A** is wrong. A has the longest path, so the largest distance, so the greatest average speed: **B** is wrong and C is right. The problem gives no information about speed at the moment of arrival, so **D** cannot be concluded.
For average velocity, look at displacement. For average speed, look at distance.
▶ **Watch 25:47, Example 11**

12. **(1) F (2) T (3) T (4) F (5) F**
(1) "Instantaneous" means an *extremely* short time, not just a short one. (2) For uniform linear motion, the velocity is the same all the time. (3) That is the definition. (4) Average speed is not the magnitude of average velocity: the two mean different things. (5) One full lap: average velocity is 0 but average speed is not.
▶ **Watch 28:34, Example 12**

One-line summary

Average velocity: displacement ÷ time (vector). Average speed: distance ÷ time (scalar). Over an extremely short time, average becomes instantaneous.

Key terms

Term	Meaning	Chinese
average velocity	displacement ÷ time; a vector	平均速度 píngjūn sùdù
average speed	distance ÷ time; a scalar	平均速率 píngjūn sùlǜ
instantaneous velocity	velocity at one instant; along the tangent	瞬时速度 shùnshí sùdù
instantaneous speed	magnitude of instantaneous velocity	瞬时速率 shùnshí sùlǜ
displacement	change of position, start to end; a vector	位移 wèiyí
distance (path length)	length of the path travelled; a scalar	路程 lùchéng
uniform linear motion	constant instantaneous velocity	匀速直线运动 yúnsù zhíxiàn yùndòng
tangent	line touching the path at one point	切线 qiēxiàn

How to Find Average Velocity of a Multi-Part Trip

Physics with Tiaotiao 跳跳 · Kinematics · High School Physics

Study sheet for the video "How to Find Average Velocity of a Multi-Part Trip": key ideas, practice questions, answers

Matches: NCERT Class 11 Ch 2 · FSc Part 1 Ch 3 · AS & A Level 9702 · WAEC/JAMB · HSC · AP Physics 1 Unit 1 · College Physics

Key ideas

Two big ways to analyze a problem: **piecewise analysis** (cut the motion into parts, e.g. a vertical throw: up = slowing down, down = speeding up) and **overall analysis** (treat the whole thing as one, e.g. a stack of blocks as one body).

This problem type trains you to see a problem as a whole.

How to spot it: **one-way straight-line motion**, and you must find the average velocity of the whole trip. You are given the average velocity of each segment. The trip is split in one of two ways: by time or by displacement.

Core idea: average velocity is always **x / t**, whether the motion is uniform or not, speeding up or slowing down.

1. Find the **total displacement** x.
2. Find the **total time** t.
3. Divide: x / t is the average velocity of the whole trip.

Keep telling yourself: look at the whole. Put all your attention on the total displacement and the total time.

Problem-solving card: multi-segment average velocity

Split by time (Example 1)



Use time to find the total displacement

Split by displacement (Example 2)



Use displacement to find the total time

Either way, end with: $\bar{v} = \frac{x}{t}$ (total displacement ÷ total time)

Split by time	Split by displacement
You are given the average velocity in each time segment. Use time to find the total displacement.	You are given the average velocity over each displacement segment. Use displacement to find the total time. The calculation is a bit harder.

Practice

Try these before checking the answers on the next page.

1. A particle moves along a straight line, always in the same direction. In the first 2/3 of the time its average velocity is v/2; in the last 1/3 of the time it is 2v. What is the average velocity of the whole trip? ( )

A. 3v/4 B. 3v/2 C. v D. 2v/3

Answer: _____ Working:

2. A particle moves along a straight line, always in the same direction. Its average velocity is v_1 over the first 1/3 of the displacement and v_2 over the last 2/3. What is the average velocity of the whole trip?

Answer: _____ Working:

3. A car drives along a straight, level road. It first travels 1/4 of the whole distance at 20 m/s, then travels the remaining 3/4 of the distance at speed v. The average velocity for the whole trip is 16 m/s. Then v equals ( )

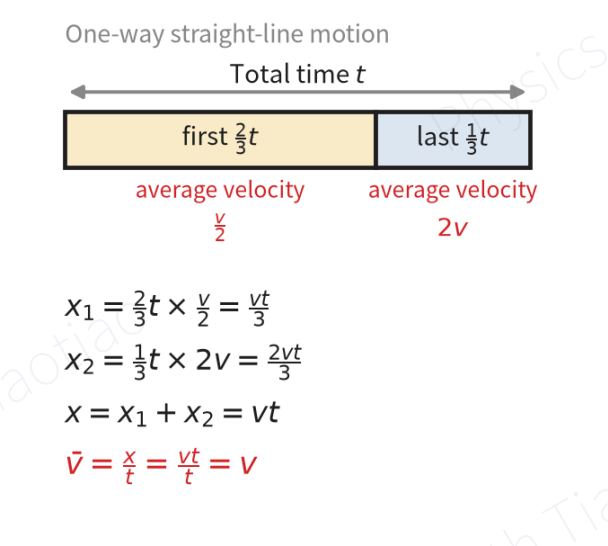
A. 18 m/s B. 36 m/s C. 15 m/s D. 17.1 m/s

Answer: _____ Working:

Answers and explanations

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

1. C. One-way straight line, and we are given time information, so split by time. Let the total time be t. Segment 1 lasts 2t/3 and segment 2 lasts t/3.
x_1 = (2t/3)(v/2) = vt/3, x_2 = (t/3)(2v) = 2vt/3, so x = x_1 + x_2 = vt. Then average velocity = x / t = v.

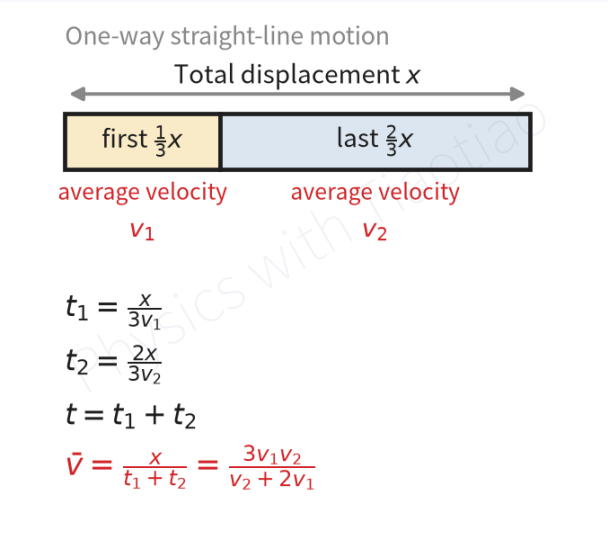


$$x_1 = \frac{2}{3}t \times \frac{v}{2} = \frac{vt}{3}$$
$$x_2 = \frac{1}{3}t \times 2v = \frac{2vt}{3}$$
$$x = x_1 + x_2 = vt$$
$$\bar{v} = \frac{x}{t} = \frac{vt}{t} = v$$

Do not average v/2 and 2v directly. Always use total displacement ÷ total time.

▶ **Watch 6:16, Example 1**

2. $3v_1v_2 / (v_2 + 2v_1)$. We are given displacement information, so split by displacement. Let the total displacement be x. Segment 1 is x/3 and segment 2 is 2x/3.
t_1 = (x/3) ÷ v_1 = x / (3v_1), t_2 = (2x/3) ÷ v_2 = 2x / (3v_2). Then average velocity = x / (t_1 + t_2). Cancel x and use a common denominator to get $3v_1v_2$ / (v_2 + 2v_1).

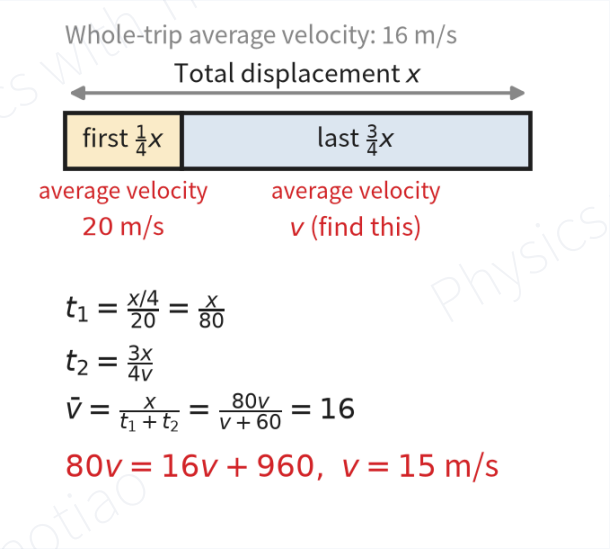


$$t_1 = \frac{x}{3v_1}$$
$$t_2 = \frac{2x}{3v_2}$$
$$t = t_1 + t_2$$
$$\bar{v} = \frac{x}{t_1 + t_2} = \frac{3v_1v_2}{v_2 + 2v_1}$$

Check: if v_1 = v_2 = v, the result is v.

▶ **Watch 8:27, Example 2**

3. C. Split by displacement. Let the total displacement be x. Then t_1 = (x/4) ÷ 20 = x/80 and t_2 = (3x/4) ÷ v = 3x/(4v).
Average velocity = x / (t_1 + t_2) = 80v / (v + 60) = 16. So 80v = 16v + 960, and v = 15 m/s.



▶ **Watch 10:49, Example 3**

One-line summary

Look at the whole: find the total displacement and the total time, then divide. Split by time → use time to find displacement. Split by displacement → use displacement to find time.

Key terms

Term	Meaning	Chinese
average velocity	total displacement divided by total time	平均速度 píngjūn sùdù
total displacement	the displacement of the whole trip	总位移 zǒng wèiyí
total time	the time of the whole trip	总时间 zǒng shíjiān
piecewise analysis	cutting a motion into parts and studying each	分段分析 fēnduàn fēnxī
overall analysis	treating the whole as one	整体分析 zhěngtǐ fēnxī
one-way straight-line motion	moving along a straight line, never turning back	单向直线运动 dānxiàng zhíxiàn yùndòng
split by time / by displacement	the two ways a trip is cut into segments	按时间 / 按位移分段 àn shíjiān / àn wèiyí fēnduàn

How to Find Change in Velocity: Why It's 7, Not 3

Physics with Tiaotiao 跳跳 · Kinematics · High School Physics

Study sheet for the video "How to Find Change in Velocity": 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 = final − initial. Pocket money goes from 3000 to 4000: the change is **+1000**. Coins go from 100 to 98: the change is **−2**. Never use initial − final.
The **sign** tells you whether it went up or down. The **number** tells you by how much.

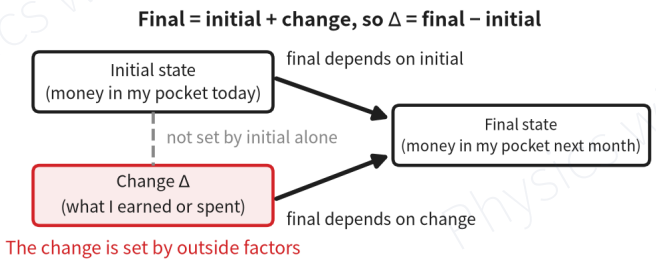
"Depends on" goes one way. The final state depends on the initial state and on the change: **final = initial + change**. So the change is found from a subtraction, but it **does not depend on the initial or final velocity alone**.

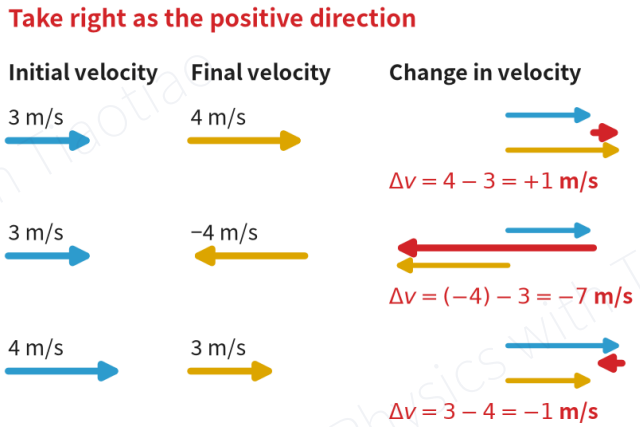
Being able to calculate a quantity is not the same as it depending on that quantity. The change is set by outside factors, for example the brake or the gas pedal.

Change in velocity Δv is an arrow (a vector). $\Delta v = v_t - v_0$, where v_0 is the initial velocity and v_t is the final velocity.
If Δv points the **same way** as v_0, the object speeds up. If Δv points the **opposite way**, the object slows down **only when the opposite arrow is shorter than the initial velocity arrow**. A longer opposite arrow means the object turns around.

Steps on a straight line.
1. Choose the positive direction (usually the direction of the initial velocity).
2. Give v_0 and v_t their signs.
3. Compute $\Delta v = v_t - v_0$.

The signs are ordinary math signs. A + sign can be dropped; a − sign cannot. On a line you only need + and −. A curve has infinitely many directions.





Practice

Try these before checking the answers on the next page.

1. Take right as positive and find Δv for each motorcycle (in km/h).

(a) It speeds up from 30 km/h rightward to 100 km/h.

(b) It slows down from 80 km/h rightward to 20 km/h rightward.

(c) It brakes and turns around, from 40 km/h rightward to 20 km/h the other way.

(a) Δv = _____ (b) Δv = _____ (c) Δv = _____

2. True or false? Write ✓ or ✗.

(1) Velocity is a vector, and change in velocity is a scalar. _____

(2) The velocity points right, and the change in velocity may point left. _____

(3) The greater the velocity, the greater the change in velocity. _____

(4) The change in velocity always points in the same direction as the final velocity. _____

(5) The greater the change in velocity, the greater the velocity. _____

3. Which statement about change in velocity (Δv) is correct? ( ) (more than one may be correct)

A. Δv is a vector; in straight-line motion, + / − signs show its direction

B. The larger the Δv, the greater the object's velocity

C. If the final velocity points right, Δv may point left

D. Δv tells how fast the velocity changes

Answer: _____ Reason:

4. A ball hits the ground at 5 m/s, moving straight down. It bounces and rises for a while, and its speed is then 2 m/s. During this process: ( ) (more than one may be correct)

A. The magnitude of Δv is 7 m/s B. The magnitude of Δv is 3 m/s

C. Δv points downward D. Δv points upward

Answer: _____ Working:

5. A particle moves in a straight line. The magnitude of its initial velocity is 2 m/s and the magnitude of its final velocity is 4 m/s. Then ( ) (more than one may be correct)

A. The magnitude of the change in velocity may be 6 m/s

B. The magnitude of the change in velocity may be 4 m/s

C. The change in velocity may point the same way as the initial velocity

D. The change in velocity may point opposite to the initial velocity

Answer: _____ Working:

Answers and explanations

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

1. (a) +70 km/h, (b) −60 km/h, (c) −60 km/h. Right is positive.
(a) $v_0 = +30$, $v_t = +100$, so $\Delta v = 100 - 30 = 70$ km/h. (b) $v_0 = +80$, $v_t = +20$, so $\Delta v = 20 - 80 = -60$ km/h.
(c) $v_0 = +40$, $v_t = -20$, so $\Delta v = -20 - 40 = -60$ km/h.

Same Δv as (b), different motion. A + sign can be dropped; a − sign cannot.

▶ **Watch 31:30, Example 1**

2. ✗ ✓ ✗ ✗ ✗ (items 1 to 5).
(1) ✗: change in velocity is also a vector, so it has a direction. (2) ✓: the velocity points right, and braking gives a Δv that points left. (3) ✗: a bullet train is fast but moves at constant velocity, so Δv = 0. (4) ✗: Δv does not have to point the way the final velocity points. For 4 m/s to 3 m/s rightward, Δv = −1 m/s points left. (5) ✗: going from 0 to 5 m/s gives a bigger Δv than going from 100 to 99 m/s, but the velocity is far smaller.

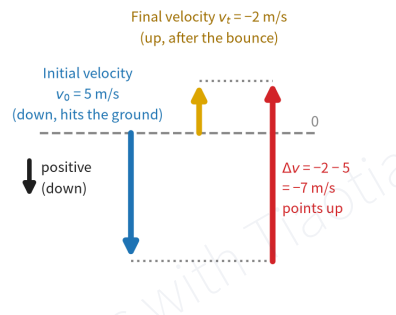
Δv is set by outside factors: think brake and gas pedal.

▶ **Watch 34:15, Example 2**

3. A and C. A is correct: Δv is a vector, and on a line the sign shows direction. C is correct: a final velocity to the right can come with a Δv to the left, for example 3 m/s right to 1 m/s right. B is wrong: Δv does not depend on the velocity alone. D is wrong: Δv is how much the velocity changes. How fast it changes is acceleration, next lesson.

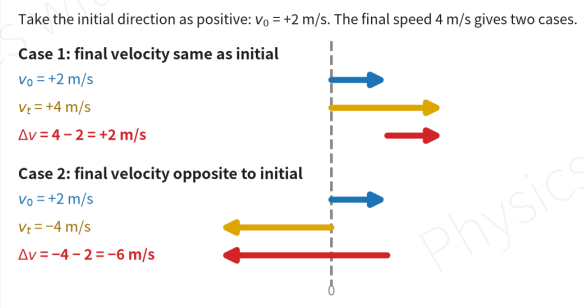
▶ **Watch 36:08, Example 3**

4. A and D. Take down as positive. $v_0 = +5$ m/s and $v_t = -2$ m/s (up is opposite to positive, so negative). $\Delta v = -2 - 5 = -7$ m/s. The magnitude is 7 m/s, and the minus sign means Δv points up.



▶ **Watch 36:58, Example 4**

5. A, C and D. Take the initial direction as positive, so $v_0 = +2$ m/s. Only magnitudes are given, so check several cases. Case 1: $v_t = +4$ m/s, so $\Delta v = 4 - 2 = +2$ m/s, the same way as v_0 (C). Case 2: $v_t = -4$ m/s, so $\Delta v = -4 - 2 = -6$ m/s, opposite to v_0 (D) with magnitude 6 m/s (A). A magnitude of 4 m/s never happens (B is wrong).



Only magnitudes given? Watch for several cases.

▶ **Watch 38:15, Example 5**

One-line summary

Change in velocity = final − initial: pick a positive direction, give both velocities their signs, subtract, and remember that outside factors set Δv.

Key terms

Term	Meaning	Chinese
change in velocity (Δv)	final velocity minus initial velocity	速度变化量 sùdù biànhuàliàng
initial velocity	the velocity at the start	初速度 chū sùdù
final velocity	the velocity at the end	末速度 mò sùdù
positive direction	the direction you choose to call +	正方向 zhèng fāngxiàng
vector / scalar	has direction / has no direction	矢量 / 标量 shǐliàng / biāoliàng
magnitude	the number part, without direction	大小 dàxiǎo

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.

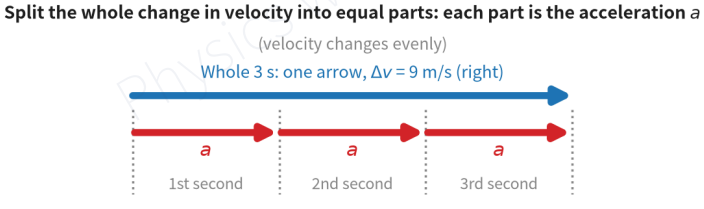
Acceleration is the rate of change of velocity. **$a = \Delta v / \Delta t$**, where a is the acceleration, Δv is the change in velocity and Δt is the time taken. The unit is m/s^2, because Δv is in m/s and Δt is in s.
Don't be fooled by the name. It can describe how fast velocity **increases** or how 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:

---

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:

---

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:

---

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.

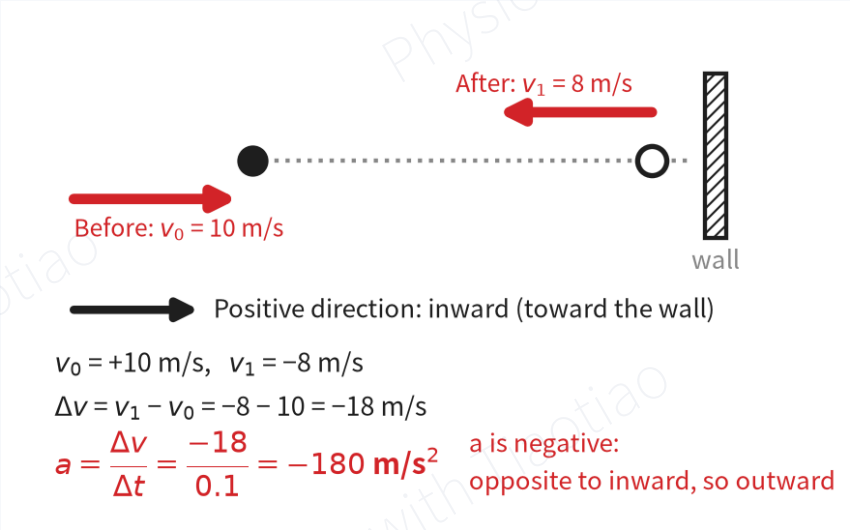
▶ **Watch 14:51, Example 1**

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.

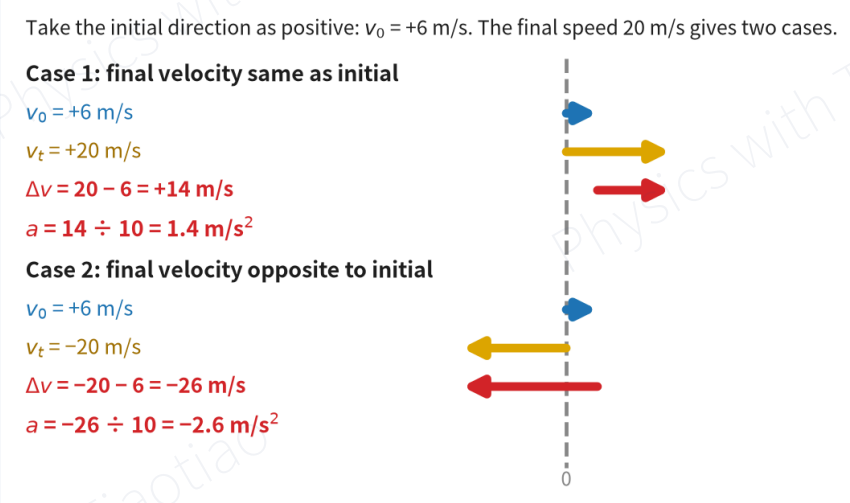
▶ **Watch 16:27, Example 2**

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

Speeding Up or Slowing Down? Check a and v

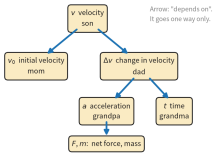
Physics with Tiaotiao 跳跳 · Kinematics · High School Physics

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

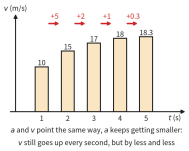
Key ideas

"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.

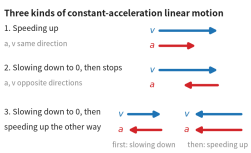
Speeding up or slowing down: look at the directions of a and v together. Same direction: speeding up. Opposite directions: slowing down. Neither v alone nor a alone is enough.
It does not matter whether a gets bigger or smaller. If a and v are opposite, v decreases even when a increases (faster and faster). 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).

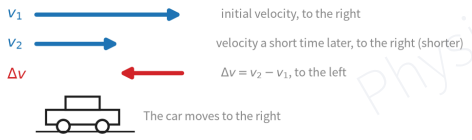


Practice

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