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Kinematics Basics

Study Guide — Kinematics

Pre-med/IB-style conceptual questions on 1D/2D kinematics: distance vs displacement, speed vs velocity, acceleration, sign conventions, motion graphs (slope/area), constant-acceleration reasoning, free fall, projectiles, and relative motion.

1 A student walks 3 m east, then 4 m west along a straight line. Which statement is correct?

A Distance = 1 m, displacement = 7 m east

B **Distance = 7 m, displacement = 1 m west** ✓

C Distance = 7 m, displacement = 1 m east

D Distance = 0 m, displacement = 0 m

E Distance = 4 m, displacement = 3 m east

▶ **Explanation:** Distance is total path length $(3 + 4 = 7$ m). Displacement is final minus initial position: 3 m east then 4 m back gives net 1 m west. Other options mix up path length with net change in position or direction.

2 A runner completes one full lap of a circular track and returns to the starting point. Which is true for the entire lap?

A Average speed = 0, average velocity 0

B **Average speed > 0, average velocity = 0** ✓

C Average speed = average velocity

D Average speed = 0 and average velocity = 0

E Average velocity is larger than average speed

▶ **Explanation:** Returning to the start means displacement is zero, so average velocity (displacement/time) is zero. Distance traveled is not zero, so average speed (distance/time) is positive.

3 Which of the following is a vector quantity?

A Speed

B Distance

C **Displacement** ✓

D Time

E Mass

▶ **Explanation:** A vector has magnitude and direction. Displacement requires direction; speed, distance, time, and mass are scalars (no direction).

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4 **Which statement about speed and velocity is correct?**

A Speed includes direction; velocity does not.

B Velocity can never be negative.

C **Speed is the magnitude of velocity and has no direction.** ✓

D Velocity is always larger than speed.

E Speed equals displacement divided by time.

▶ **Explanation:** Speed is a scalar (magnitude only). Velocity is a vector (includes direction, so it can be negative in 1D). Speed relates to distance/time, not displacement/time.

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5 **A car travels 60 km east in 1 hour, then 60 km west in 1 hour. Which statement is correct for the whole 2-hour trip?**

A Average speed = 0 km/h, average velocity = 0 km/h

B Average speed = 30 km/h, average velocity = 30 km/h east

C Average speed = 120 km/h, average velocity = 0 km/h

D **Average speed = 60 km/h, average velocity = 0 km/h** ✓

E Average speed = 0 km/h, average velocity = 60 km/h

▶ **Explanation:** Total distance = 120 km in 2 h → average speed = 60 km/h. Net displacement is zero (back to start) → average velocity = 0.

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6 **In 1D motion, which statement about a negative velocity is correct?**

A Negative velocity means the object is slowing down.

B Negative velocity means the object is speeding up.

C **Negative velocity means motion is opposite the chosen positive direction.** ✓

D Negative velocity means the speed is negative.

E Negative velocity is impossible in physics.

▶ **Explanation:** The sign of velocity indicates direction relative to your chosen axis. Speed is the magnitude and cannot be negative; speeding up/slowing down depends on velocity and acceleration together.

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7 **Acceleration is best defined as:**

A Distance traveled per unit time

B Displacement per unit time

C **Change in velocity per unit time** ✓

D Change in distance per unit time

E Velocity divided by displacement

▶ **Explanation:** Acceleration measures how velocity changes with time (it includes changes in speed and/or direction). Options A and B define speed and velocity.

8 **Which situation shows zero velocity but nonzero acceleration?**

A A car moving straight at constant 20 m/s

B **A ball at the highest point of its vertical throw (ignoring air)** ✓

C A book resting on a table

D A cart moving straight with constant speed and constant direction

E A train moving on a straight track with constant velocity

▶ **Explanation:** At the top of a throw, instantaneous velocity is zero, but gravitational acceleration still acts downward (about 9.8 m/s^2). Resting objects have zero acceleration too (net force zero).

9 **Which situation shows nonzero velocity but zero acceleration?**

A A car increasing speed on a straight road

B A cyclist turning a corner at constant speed

C **A train moving straight at constant velocity** ✓

D A ball falling freely (ignoring air)

E A rocket changing direction in space

▶ **Explanation:** Zero acceleration means velocity is not changing. Straight-line constant-velocity motion has nonzero velocity but zero acceleration. Turning at constant speed still changes velocity direction, so acceleration is not zero.

10 **An object moves in a circle at constant speed. Which statement is correct?**

A Acceleration is zero because speed is constant.

B Velocity is constant because speed is constant.

C **The object accelerates because velocity direction changes. ✓**

D Displacement after any time must be zero.

E Distance traveled must be zero because it returns to the start each second.

▶ **Explanation:** Velocity is a vector. In circular motion the direction of velocity changes continuously, so there is acceleration (toward the center) even if speed stays constant.

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⑪ **On a displacement–time graph, the slope (gradient) represents:**

A Acceleration

B **Velocity ✓**

C Displacement

D Distance

E Momentum

▶ **Explanation:** Slope is Δ(displacement)$/\Delta$(time), which is velocity. Acceleration comes from changes in slope over time (curvature).

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⑫ **On a velocity–time graph, the slope (gradient) represents:**

A Displacement

B Speed

C **Acceleration ✓**

D Distance

E Kinetic energy

▶ **Explanation:** Slope is Δ(velocity)/Δ(time), which is acceleration. Area under v–t relates to displacement, not slope.

13 On a velocity–time graph, the area under the curve between two times represents:

A Acceleration

B **Displacement** ✓

C Speed

D Force

E Momentum

▶ **Explanation:** Area under v–t is v dt, which gives displacement. If velocity changes sign, areas above and below the axis subtract, giving net displacement.

14 On an acceleration–time graph, the area under the curve between two times represents:

A **Change in velocity** ✓

B Displacement

C Average speed

D Kinetic energy

E Mass

▶ **Explanation:** Area under a–t is a dt $= \Delta$v. Displacement would require integrating velocity, not acceleration.

15 A displacement–time graph is a horizontal line. What does this indicate?

A Constant nonzero velocity

B Increasing acceleration

C The object is at rest (velocity = 0) ✓

D The object is speeding up

E The object must be moving in a circle

▶ **Explanation:** Horizontal means displacement is not changing with time, so slope is zero → velocity is zero. It does not imply anything about circular motion.

16 A displacement–time graph is a straight line with constant positive slope. What does this indicate?

A **Constant positive velocity (and zero acceleration)** ✓

B Constant positive acceleration

C Constant negative velocity

D Velocity increasing with time

E Displacement must be zero

▶ **Explanation:** Straight line means constant slope → constant velocity. If velocity is constant, acceleration is zero (in 1D).

17 A displacement–time graph curves upward (its slope increases with time). Which statement is correct?

A Velocity is constant and positive

B Velocity is decreasing but still positive

C **Velocity is increasing (positive acceleration)** ✓

D Acceleration must be zero because displacement increases

E The object must be moving with constant speed

▶ **Explanation:** Increasing slope means velocity is increasing. In 1D, increasing velocity with time corresponds to positive acceleration.

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18 **A displacement–time graph increases but curves downward (its slope decreases with time while remaining positive). Which statement is correct?**

A **Velocity is positive but decreasing (negative acceleration)** ✓

B Velocity is negative

C Acceleration must be positive

D The object is at rest

E Displacement must be decreasing

▶ **Explanation:** The graph still rises, so velocity is positive. But the slope is getting smaller, so velocity is decreasing; that means acceleration is negative (in the chosen positive direction).

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19 **A velocity–time graph is a horizontal line at v = +5 m/s. Which is true?**

A Acceleration is $+5$ m/s^2

B **Acceleration is zero** ✓

C Velocity is increasing

D Displacement is zero

E The object must be slowing down

▶ **Explanation:** A horizontal v–t line has zero slope, so acceleration is zero. Displacement is not zero; it increases linearly (area under the graph).

20 A velocity–time graph is a straight line with positive slope. Which statement is correct?

A **Acceleration is constant and positive** ✓

B Acceleration is zero

C Acceleration is constant and negative

D Velocity must be constant

E Displacement must be zero

▶ **Explanation:** A straight line has constant slope, so acceleration is constant. Positive slope means positive acceleration.

21 A velocity–time graph crosses from positive velocity to negative velocity. What must be true at the crossing point?

A Acceleration is zero

B Displacement is zero

C **Velocity is zero (instantaneous stop/change of direction)** ✓

D Speed is negative

E The object is at equilibrium

▶ **Explanation:** Crossing the time axis on a v–t graph means $v = 0$ at that instant. Acceleration may or may not be zero there (it depends on the slope).

22 **Which statement is guaranteed for 1D motion with constant acceleration?**

A   The displacement–time graph is a straight line

B   **The velocity–time graph is a straight line** ✓

C   The acceleration–time graph must cross zero

D   The speed must be constant

E   The object must return to its starting point

▶ **Explanation:** Constant acceleration means velocity changes linearly with time, so v–t is a straight line. Displacement–time is curved (parabolic) for nonzero constant acceleration.

23 **A velocity–time graph has equal positive area above the time axis and equal negative area below the time axis over the same time interval. What can you conclude?**

A   Displacement is zero, distance traveled is zero

B   **Displacement is zero, but distance traveled is greater than zero** ✓

C   Displacement is greater than zero

D   Distance traveled is negative

E   Acceleration must be zero the whole time

▶ **Explanation:** Displacement is the signed area under v–t, so equal positive and negative areas cancel → displacement 0. Distance counts total path length, so it adds magnitudes and is positive.

24 **If acceleration is zero in 1D motion, which statement is always true?**

A   **Velocity is constant (could be zero)** ✓

B Speed must be increasing

C The object must be at rest

D Displacement must be zero

E The object must be moving in a circle

▶ **Explanation:** Zero acceleration means no change in velocity, so velocity stays constant. It can be constant and nonzero (uniform motion) or constant and zero (rest).

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25 **If velocity is constant in 1D motion, what must be true about acceleration?**

A Acceleration is constant and nonzero

B **Acceleration is zero** ✓

C Acceleration equals velocity

D Acceleration must be positive

E Acceleration must be negative

▶ **Explanation:** Acceleration is the rate of change of velocity. If velocity is constant, its change is zero, so acceleration is zero.

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26 **For 1D motion with constant acceleration, what is the average velocity over a time interval in terms of initial velocity u and final velocity v?**

A vavg = u + v

B **vavg = (u + v)/2** ✓

C vavg = (v − u)/2

D vavg = uv

E vavg = u/v

▶ **Explanation:** With constant acceleration, velocity changes linearly with time, so the time-average of velocity is the midpoint value: $(u + v)/2$.

27 **An object starts from rest and moves with constant acceleration. If the time of motion is doubled, the displacement becomes:**

A 2 times larger

B 3 times larger

C **4 times larger** ✓

D 8 times larger

E Unchanged

▶ **Explanation:** From rest with constant acceleration, displacement $s = (1/2)at^2$, so $s \propto t^2$. Doubling t multiplies s by $2^2 = 4$.

28 **An object starts from rest with constant acceleration. The distances traveled in successive equal time intervals are in which ratio?**

A 1 : 1 : 1 : 1

B 1 : 2 : 3 : 4

C **1 : 3 : 5 : 7** ✓

D 1 : 4 : 9 : 16

E 2 : 4 : 6 : 8

▶ **Explanation:** With constant acceleration from rest, displacement grows like t^2. Differences between squares (1^2, 2^2, 3^2, 4^2) are 1, 3, 5, 7, giving the distance each equal time step.

29 A ball is thrown straight up. Ignoring air resistance, which statement about the acceleration is correct during the entire flight?

A   Acceleration is upward on the way up and downward on the way down

B   Acceleration is zero at the top and nonzero elsewhere

C   **Acceleration is constant downward throughout (approximately g)** ✓

D   Acceleration is constant upward throughout

E   Acceleration depends on the speed, so it continuously changes

▶ **Explanation:** In free flight without air resistance, the only acceleration is gravity, which is constant downward near Earth. Velocity changes sign, but acceleration does not.

30 At the highest point of a vertical throw (ignoring air), which combination is correct?

A $v = 0$, $a = 0$

B $v > 0$, $a < 0$

C   **$v = 0$, $a < 0$** ✓

D $v < 0$, $a = 0$

E $v < 0$, $a > 0$

▶ **Explanation:** At the top, the instantaneous velocity is zero, but gravity still accelerates the ball downward (negative if up is positive).

31 A stone is dropped from rest (ignore air). After 1 s its speed is v. After 2 s, its speed is closest to:

A   v/2

B v

C **2v** ✓

D 4v

E v^2

▶ **Explanation:** With constant acceleration from rest, velocity grows linearly with time: v   t. Doubling time doubles speed.

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32 **Ignoring air resistance, which statement about free fall near Earth is correct?**

A Heavier objects fall faster because they have more weight

B **All objects fall with the same constant acceleration g, independent of mass** ✓

C Acceleration increases with time because objects speed up

D Acceleration is zero because gravity is constant

E Objects fall at constant speed

▶ **Explanation:** Without air resistance, gravitational acceleration near Earth is approximately constant (g) and does not depend on the object's mass. Weight affects force, but acceleration is the same.

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33 **In projectile motion without air resistance, which statement is correct?**

A Horizontal acceleration equals g

B **Horizontal velocity is constant; vertical acceleration is constant downward** ✓

C Vertical velocity is constant; horizontal acceleration is downward

D Both horizontal and vertical accelerations are zero

E Horizontal and vertical motions are not independent

▶ **Explanation:** Gravity acts only vertically, so ax = 0 (horizontal velocity constant), while ay = −g (vertical acceleration constant downward).

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34 **A projectile is launched and lands back at the same vertical level (ignore air). Which statement is correct?**

A Time going up is greater than time coming down

B **Time going up equals time coming down** ✓

C Time coming down is zero at maximum height

D Time depends only on horizontal speed

E Time depends only on mass

▶ **Explanation:** With constant downward acceleration and symmetric start/end heights, vertical motion is symmetric: the time to rise to $v_y = 0$ equals the time to fall back to the launch height.

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35 **Two projectiles are launched from the same point with the same speed, one at angle and one at angle (90° −) (ignore air). Their ranges are:**

A **Equal** ✓

B The projectile always goes farther

C The (90° −) projectile always goes farther

D Both have zero range

E Range depends only on mass, so cannot compare

▶ **Explanation:** For launch and landing at the same height with no air, range sin(2). Since sin(2) = sin(180° − 2) = sin(2(90° −)), complementary angles give the same range.

36 Two cars move east at 20 m/s and 15 m/s. What is the speed of the faster car relative to the slower car?

A **5 m/s** ✓

B 15 m/s

C 20 m/s

D 35 m/s

E 0 m/s

▶ **Explanation:** Relative speed in the same direction is the difference in speeds: $20 - 15 = 5$ m/s. Adding (35 m/s) applies to opposite directions.

37 Car A moves east at 20 m/s while car B moves west at 15 m/s. What is the speed of A relative to B?

A 5 m/s

B 15 m/s

C 20 m/s

D **35 m/s** ✓

E 0 m/s

▶ **Explanation:** For opposite directions, relative speed adds: $20 + 15 = 35$ m/s. The difference applies only when moving in the same direction.

38 A train moves 10 m/s east. A person walks 2 m/s west relative to the train. The person's velocity relative to the ground is:

A 12 m/s east

B 10 m/s east

C **8 m/s east** ✓

D 2 m/s west

E 8 m/s west

▶ **Explanation:** Take east as positive. $v_{person}/ground = v_{train}/ground + v_{person}/train = +10 + (-2) = +8$ m/s (east).

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39 Which situation can have zero average velocity but nonzero average speed?

A Moving in a straight line without ever turning around

B **Returning to the starting point after moving away (out-and-back trip)** ✓

C Standing still for the entire time

D Moving at constant velocity in one direction

E Having constant acceleration in one direction without reversing

▶ **Explanation:** Zero average velocity means displacement is zero, which happens when you end where you started. You can still travel a positive distance, giving a positive average speed.

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40 Which situation can have zero average speed but nonzero average velocity over a time interval?

A Moving out and coming back

B Moving with constant velocity

C Oscillating about a point and ending elsewhere

D **This is impossible** ✓

E Falling freely under gravity

► **Explanation:** Average speed = distance/time. For average speed to be zero, distance must be zero (no motion), which forces displacement to be zero too, so average velocity cannot be nonzero.

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41 **A car travels 100 km at 50 km/h, then returns 100 km at 100 km/h. What is the average speed for the whole trip?**

A   50 km/h

B   75 km/h

C   **200/3 km/h ✓**

D   100 km/h

E   150 km/h

► **Explanation:** Average speed = total distance / total time. Time out = 100/50 = 2 h, time back = 100/100 = 1 h, total time = 3 h. Total distance = 200 km, so average speed = 200/3 km/h (less than the arithmetic mean 75).

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42 **For the same out-and-back trip (100 km out, 100 km back), what is the average velocity for the whole trip?**

A   50 km/h

B   200/3 km/h

C   75 km/h

D   **0 km/h ✓**

E   100 km/h

► **Explanation:** Average velocity depends on displacement, not distance. Returning to the starting point makes displacement zero, so average velocity is zero.

43 A car drives in the same direction for equal times: 1 hour at 50 km/h, then 1 hour at 100 km/h. What is the average speed?

A 50 km/h

B 75 km/h ✓

C 200/3 km/h

D 100 km/h

E 150 km/h

▶ **Explanation:** For equal times, average speed is the arithmetic mean: $(50 + 100)/2 = 75$ km/h. The 200/3 result applies to equal distances, not equal times.

44 A cyclist rides 10 km north then 10 km east. Which statement is correct?

A Distance = 20 km and displacement magnitude = 20 km

B Distance = 20 km and displacement magnitude = 10 km

C Distance = 20 km and displacement magnitude = 10√2 km ✓

D Distance = 10√2 km and displacement magnitude = 20 km

E Distance = 0 km and displacement magnitude = 0 km

▶ **Explanation:** Distance is the path length: $10 + 10 = 20$ km. Displacement is straight-line from start to finish: a right triangle with legs 10 and 10, so magnitude is $\sqrt{(10^2 + 10^2)} = 10\sqrt{2}$ km.

45 Which pair must have the same SI units?

A Velocity and acceleration

B **Displacement and distance** ✓

C Speed and time

D Acceleration and force

E Velocity and energy

▶ **Explanation:** Displacement and distance are both lengths (meters). Velocity is m/s and acceleration is m/s^2, so they differ; force and energy have different units from acceleration and velocity.

46 **Which equation is dimensionally consistent (units work out correctly)?**

A **v = u + at** ✓

B v = u + a/t

C s = ut + a

D a = v + u

E t = u + v

▶ **Explanation:** In v = u + at, units match: $(m/s) = (m/s) + (m/s^2)(s)$. The other options add or divide quantities with incompatible units.

47 **Which constant-acceleration equation relates v, u, a, and s but does NOT include time t?**

A v = u + at

B s = ut + (1/2)at^2

C **v^2 = u^2 + 2as** ✓

D s = (u + v)t/2

E a = (v − u)/t

▶ **Explanation:** $v^2 = u^2 + 2as$ links speeds, acceleration, and displacement without needing time. The others all include t explicitly.

48 **Which constant-acceleration equation relates s, u, v, and t but does NOT include acceleration a?**

A $s = (u + v)t/2$ ✓

B $v = u + at$

C $s = ut + (1/2)at^2$

D $v^2 = u^2 + 2as$

E $a = (v - u)/t$

▶ **Explanation:** s = average velocity × time = $((u + v)/2)t$, and it does not contain a. The other options include acceleration explicitly or implicitly.

49 **A velocity–time graph is a rectangle of height v and width t (constant velocity v for time t). What is the displacement?**

A $v + t$

B v/t

C   **vt** ✓

D $v^2 t$

E t/v

▶ **Explanation:** Displacement equals area under v–t: rectangle area = height × width = v × t.

50 A velocity–time graph is a triangle: velocity increases linearly from 0 to v over time t. What is the displacement over this time?

A   vt

B   **(1/2)vt** ✓

C   v/t

D   2vt

E v^2t

▶ **Explanation:** Displacement is the area under v–t. A triangle's area is $(1/2) \times$ base $\times$ height $= (1/2) \times t \times v$.

51 Velocity changes linearly from +v to −v over time t. What is the displacement over that time interval?

A   vt

B   (1/2)vt

C   **0** ✓

D   −vt

E   Cannot be determined without mass

▶ **Explanation:** For a straight line from +v to −v, the average velocity is $(v + (-v))/2 = 0$, so displacement $= v_{avg} \times t = 0$. Equivalently, the positive and negative areas cancel.

52 Velocity changes linearly from +v to −v over time t. What is the total distance traveled in that time interval?

A   0

B vt

C **(1/2)vt** ✓

D (1/4)vt

E 2vt

▶ **Explanation:** Distance is area under the speed–time graph (use |v|). The graph crosses zero at t/2, giving two equal triangles: $2 \times [(1/2)(t/2)(v)] = vt/2$.

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53 **A car's speedometer reads 0 at an instant. Which statement could still be true at that instant?**

A Acceleration must be zero

B The car must be at the top of a hill

C **The car could have nonzero acceleration** ✓

D The car must be moving backward

E The car must have zero displacement

▶ **Explanation:** Speed 0 means instantaneous velocity magnitude is 0, but acceleration can be nonzero (e.g., just as the car changes direction or starts moving).

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54 **If an object has constant nonzero acceleration in 1D, which statement about its velocity is correct?**

A Velocity is constant

B **Velocity changes linearly with time** ✓

C Velocity changes exponentially with time

D Velocity must be zero

E Velocity cannot change sign

▶ **Explanation:** Constant acceleration means $v = u + at$, which is a straight-line (linear) relation in time. Velocity can even cross zero and change sign if acceleration opposes motion long enough.

55 **If an object has constant nonzero velocity in 1D, which statement about its displacement is correct?**

A Displacement changes quadratically with time

B **Displacement changes linearly with time** ✓

C Displacement stays constant

D Displacement must be negative

E Displacement depends on acceleration, not velocity

▶ **Explanation:** With constant velocity, displacement $s = vt$ (plus an initial position), so it changes linearly with time.

56 **An object moves in the +x direction but slows down. What are the signs of velocity and acceleration?**

A $v > 0$, $a > 0$

B **$v > 0$, $a < 0$** ✓

C $v < 0$, $a > 0$

D $v < 0$, $a < 0$

E $v = 0$, $a = 0$

▶ **Explanation:** Moving in +x means $v > 0$. Slowing down means acceleration is opposite the velocity, so $a < 0$.

57 An object moves in the −x direction and speeds up (its speed increases while moving more negative). What are the signs of velocity and acceleration?

A v > 0, a > 0

B v > 0, a < 0

C **v < 0, a < 0** ✓

D v < 0, a > 0

E v = 0, a < 0

▶ **Explanation:** Moving in −x means v < 0. Speeding up means acceleration has the same sign as velocity (it pushes the velocity further negative), so a < 0.

58 An object moves in the −x direction but slows down (its velocity is negative but increases toward zero). What are the signs of velocity and acceleration?

A **v < 0, a > 0** ✓

B v < 0, a < 0

C v > 0, a < 0

D v > 0, a > 0

E v = 0, a = 0

▶ **Explanation:** Velocity is negative (motion in −x). Slowing down means acceleration is opposite to velocity, so acceleration must be positive (toward +x).

59 At a turning point in continuous 1D motion (the moment an object reverses direction), what must be true at that instant?

A Acceleration must be zero

B **Velocity must be zero** ✓

C Speed must be maximum

D Displacement must be zero

E Distance traveled must be zero

▶ **Explanation:** To switch direction smoothly in 1D, the velocity must pass through zero. Acceleration does not have to be zero (e.g., top of a throw).

60 Which statement about displacement is correct?

A Displacement equals distance traveled

B Displacement depends on the path taken

C **Displacement depends only on initial and final positions** ✓

D Displacement can never be negative

E Displacement is always greater than or equal to distance

▶ **Explanation:** Displacement is a vector from start to finish and ignores the path. Its magnitude is always less than or equal to distance traveled, and it can be negative in 1D depending on direction.

61 A person walks 5 m east, then 5 m north, then 5 m west. What is the displacement from the start?

A 0 m

B 5 m east

c **5 m north** ✓

D 15 m

E 5√2 m northeast

▶ **Explanation:** The east and west parts cancel (5 east then 5 west). Only 5 m north remains, so displacement is 5 m north.

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62 **An object moves in a straight line at 3 m/s for 4 s, then 1 m/s for 2 s (same direction). What is its average speed over the 6 s?**

A 2 m/s

B **7/3 m/s** ✓

C 3/2 m/s

D 4/3 m/s

E 5 m/s

▶ **Explanation:** Distance = 3×4 + 1×2 = 12 + 2 = 14 m. Time = 6 s. Average speed = 14/6 = 7/3 m/s.

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63 **Two balls are released from the same height at the same time. One is dropped straight down, the other is thrown horizontally. Ignoring air resistance, which hits the ground first?**

A The dropped ball

B The horizontally-thrown ball

C **They hit at the same time** ✓

D It depends on their masses

E It depends on the horizontal speed

> ▶ **Explanation:** Vertical motion is independent of horizontal motion (no air). Both start with the same vertical velocity (0) and have the same vertical acceleration (g), so they take the same time to fall.

64 **Why do the dropped ball and the horizontally-thrown ball (from the same height, no air) hit the ground at the same time?**

- **A** Because horizontal motion cancels gravity

- **B** Because the horizontally-thrown ball has a smaller weight

- **C** **Because they have identical vertical motion: same initial vertical velocity and same vertical acceleration** ✓

- **D** Because the thrown ball has no acceleration

- **E** Because they travel the same distance in the same path

> ▶ **Explanation:** Gravity acts vertically only, so the time to hit the ground depends only on the vertical drop, initial vertical velocity, and g. Horizontal velocity does not change the vertical fall time.

65 **A ball is thrown straight up from the ground with speed u (ignore air). When it returns to the ground, its speed is:**

- **A** 0

- **B** Less than u

- **C** **Equal to u** ✓

- **D** Greater than u

- **E** Impossible to predict without mass

> ▶ **Explanation:** With no air resistance and returning to the same height, the motion is symmetric: the ball returns with the same speed magnitude as it was launched, but in the opposite direction.

66 On a displacement–time graph, when is the object moving in the negative direction?

A When the graph is above the time axis

B When the graph is below the time axis

C **When the slope of the graph is negative** ✓

D When the slope of the graph is zero

E When the graph is curved

▶ **Explanation:** Direction of motion is given by velocity, which is the slope of the displacement–time graph. Negative slope means negative velocity (motion in the negative direction).

67 On a velocity–time graph, an object is speeding up (its speed is increasing) when:

A Velocity is positive

B Acceleration is zero

C **Velocity and acceleration have the same sign** ✓

D Velocity and acceleration have opposite signs

E Velocity crosses zero

▶ **Explanation:** Speed increases when the magnitude of velocity increases. In 1D, that happens when acceleration pushes velocity further in its current direction, i.e., v and a share the same sign.

68 An object has velocity $v > 0$ but acceleration $a < 0$. Which description is correct?

A Moving forward and speeding up

B **Moving forward and slowing down** ✓

C Moving backward and speeding up

D Moving backward and slowing down

E At rest with increasing speed

▶ **Explanation:** $v > 0$ means motion in the positive direction. $a < 0$ means acceleration is opposite velocity, so the speed decreases (slowing down).

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69 **Which change increases the magnitude of acceleration for the same change in velocity Δv?**

A Increase the time interval Δt

B **Decrease the time interval Δt** ✓

C Reverse the direction of motion without changing Δt

D Keep Δv and Δt the same

E Increase mass

▶ **Explanation:** Acceleration magnitude is $|a| = |\Delta v|/\Delta t$. With the same Δv, a larger acceleration requires a smaller Δt.

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70 **Which statement correctly distinguishes uniform speed from uniform velocity?**

A Uniform speed means constant direction; uniform velocity means changing direction

B Uniform speed and uniform velocity mean the same thing

C **Uniform speed means constant speed; uniform velocity means constant speed and constant direction** ✓

D Uniform speed requires zero acceleration; uniform velocity requires nonzero acceleration

E Uniform velocity is always greater than uniform speed

▶ **Explanation:** Speed is a scalar, so "uniform speed" only fixes the magnitude. Velocity is a vector, so "uniform velocity" requires both constant magnitude and constant direction (no change in velocity).