PICK PREP

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NEET PHYSICS MCQ

MOTION IN A STRAIGHT LINE

MULTIPLE CHOICE QUESTIONS

CONCEPT-BASED | FORMULA-BASED | RATIO & COMPARISON

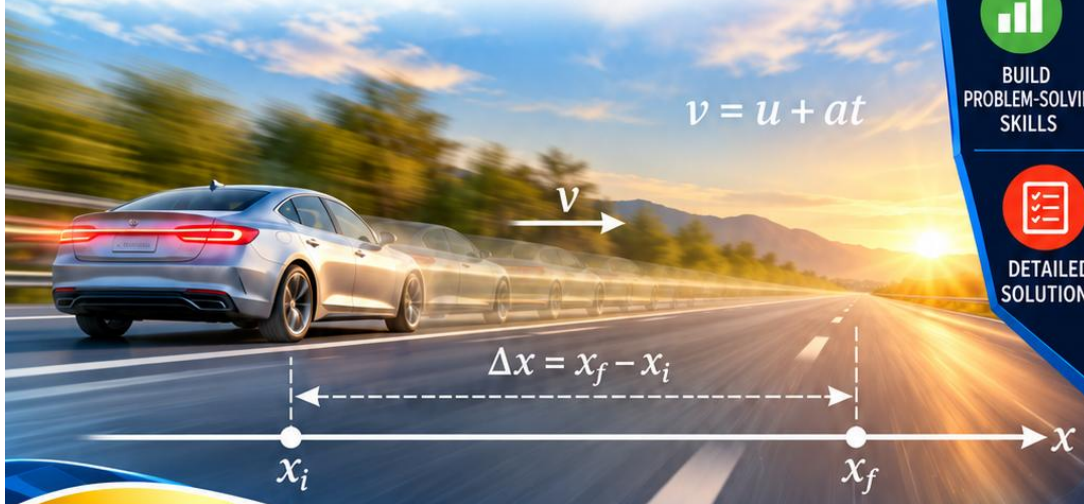
NEET-STYLE QUESTIONS | COMMON TRAPS | DETAILED SOLUTIONS

PRACTICE KEY CONCEPTS

RECOGNIZE THE PATTERN

BUILD PROBLEM-SOLVING SKILLS

DETAILED SOLUTIONS



WITH DETAILED SOLUTIONS

PRACTICE SMART.

SCORE HIGHER.

MOTION IN A STRAIGHT LINE

A. Core concepts

Q01. A particle moves along the x-axis from an initial position coordinate $x_1 = -4$ m to a final position coordinate $x_2 = +7$ m. What is the net position change (signed displacement Δx)?

A) $+3$ m B) $+11$ m C) -11 m D) $+4$ m

Q01. Physics Path →

The displacement is the change in position: final minus initial.

$$\Delta x = x_2 - x_1 = (+7) - (-4) = +11 \text{ m}$$

Answer: (B) +11 m

Q02.A car travels a total distance of 120 km. It covers the first 60 km at a constant speed of 30 km/h and the remaining 60 km at a constant speed of 60 km/h. What is the overall average speed for the entire trip?

A) 40 km/h B) 45 km/h

C) 50 km/h D) 55 km/h

Q02. Physics Path →

Average speed is total distance ÷ total time.

Time for first 60 km at 30 km/h:

$$t_1 = \frac{60}{30} = 2 \text{ h}$$

Time for next 60 km at 60 km/h:

$$t_2 = \frac{60}{60} = 1 \text{ h}$$

Total time = 2 + 1 = 3 h.

$$v_{avg} = \frac{120}{3} = 40 \text{ km/h}$$

Answer: (A) 40 km/h

Q03. The position of a particle moving along a straight line is given by $x(t) = 2t^3 - 4t + 5$ meters. What is the instantaneous velocity of the particle at time $t = 2$ s?

A) 12 m/s B) 20 m/s C) 24 m/s D) 28 m/s

Q03. Physics Path →

Instantaneous velocity is the time derivative of position.

$$v(t) = \frac{dx}{dt} = \frac{d}{dt}(2t^3 - 4t + 5) = 6t^2 - 4$$

At $t = 2$ s:

$$v(2) = 6(2^2) - 4 = 24 - 4 = 20 \text{ m/s}$$

Answer: (B) 20 m/s

Q04. The velocity of a particle is given as a function of time by $v(t) = 3t^2 + 5t - 2$ m/s. What is the instantaneous acceleration of the particle at $t = 3$ s?

A) 11 m/s^2 B) 17 m/s^2

C) 23 m/s^2 D) 32 m/s^2

Q04. Physics Path →

Instantaneous acceleration is the derivative of velocity with respect to time.

$$a(t) = \frac{dv}{dt} = \frac{d}{dt}(3t^2 + 5t - 2) = 6t + 5$$

At $t = 3$ s:

$$a(3) = 6(3) + 5 = 18 + 5 = 23 \text{ m/s}^2$$

Answer: (C) 23 m/s²

Q05. Two identical cars start from rest at the same point and move with the same constant acceleration. If the time elapsed for Car 2 is twice that of Car 1 ($t_2 = 2t_1$), what is the ratio of their final velocities ($v_2 : v_1$) and displacements ($s_2 : s_1$) respectively?

A) $2:1$ and $2:1$ B) $2:1$ and $4:1$

C) $4:1$ and $2:1$ D) $4:1$ and $16:1$

Q05. Physics Path →

For constant acceleration:

- Final velocity: $v = at$. So, $v_2/v_1 = t_2/t_1 = 2/1 = 2:1$.
- Displacement: $s = \frac{1}{2}at^2$. So, $s_2/s_1 = (t_2/t_1)^2 = (2/1)^2 = 4:1$.

Answer: (B) 2:1 and 4:1

Q06. A projectile is thrown vertically upward with initial speed u and returns to its launch level after flight time T, reaching maximum rise H. If the initial projection speed is doubled ($u' = 2u$) while keeping g constant, by what factor do the total flight time T and maximum rise H increase?

A) T increases by 2 times; H increases by 2 times

B) T increases by 2 times; H increases by 4 times

C) T increases by 4 times; H increases by 2 times

D) T increases by 4 times; H increases by 4 times

Q06. Physics Path →

For vertical projectile motion:

- Flight time: $T = \frac{2u}{g}$. If $u' = 2u$, then $T' = \frac{2(2u)}{g} = 2T$.

- Maximum height: $H = \frac{u^2}{2g}$. If $u' = 2u$, then $H' = \frac{(2u)^2}{2g} = 4H$.

So, flight time doubles, and maximum height becomes four times.

Answer: (B) T increases by 2 times; H increases by 4 times

Q07. Two runners are separated by an initial distance of 100 m on a straight track and move towards each other with constant speeds of 4 m/s and 6 m/s respectively. If their initial separation is doubled (200 m) while their individual speeds are also doubled (8 m/s and 12 m/s), how does their meeting time change?

A) Doubled

B) Halved

C) Unchanged

D) Quadrupled

Q07. Physics Path →

Meeting time depends on initial separation ÷ relative speed.

- Case 1: Separation = 100 m, relative speed = $4 + 6 = 10$ m/s.

$$t_1 = \frac{100}{10} = 10 \text{ s}$$

Case 2: Separation = 200 m, relative speed = $8 + 12 = 20$ m/s.

$$t_2 = \frac{200}{20} = 10 \text{ s}$$

So, the meeting time remains unchanged.

Answer: (C) Unchanged

Q08. Case A involves a journey covered in two equal *distances* at speeds 20 m/s and 30 m/s. Case B involves a journey covered in two equal *time intervals* at speeds 20 m/s and 30 m/s. What are the average speeds in Case A ($\bar{v}_A$) and Case B ($\bar{v}_B$)?

A) $\bar{v}_A = 24$ m/s; $\bar{v}_B = 25$ m/s

B) $\bar{v}_A = 25$ m/s; $\bar{v}_B = 24$ m/s

C) $\bar{v}_A = 24$ m/s; $\bar{v}_B = 24$ m/s

D) $\bar{v}_A = 25$ m/s; $\bar{v}_B = 25$ m/s

Q08. Physics Path →

- Case A (equal distances): Average speed is harmonic mean of two speeds.

$$\bar{v}_A = \frac{2v_1v_2}{v_1 + v_2} = \frac{2(20)(30)}{20 + 30} = \frac{1200}{50} = 24 \text{ m/s}$$

- Case B (equal times): Average speed is arithmetic mean of two speeds.

$$\bar{v}_B = \frac{v_1 + v_2}{2} = \frac{20 + 30}{2} = 25 \text{ m/s}$$

Answer: (A) $\bar{v}_A = 24$ m/s; $\bar{v}_B = 25$ m/s

Q09. Which of the following mathematical operations correctly yields the instantaneous velocity of a particle from its position-time function $x(t)$?

A) Evaluating the total position change divided by total time elapsed ($\Delta x/\Delta t$)

B) Taking the first time derivative of the position function (dx/dt)

C) Integrating the position function with respect to time ($\int x\,(t)\,dt$)

D) Multiplying position by acceleration

Q09. Physics Path →

Instantaneous velocity is obtained by differentiating position with respect to time, not by average change or integration.

$$v(t) = \frac{dx}{dt}$$

Answer: (B) Taking the first time derivative of the position function (dx/dt)

Q10. Why is the total distance travelled by an oscillating particle in one-dimensional motion generally greater than or equal to the magnitude of its net position change ($\Delta x = x_2 - x_1$)?

A) Because displacement is a scalar quantity while distance is a vector

B) Because distance accumulates path length positively regardless of direction, whereas signed displacement accounts for directional reversals where backward motion cancels forward position change

C) Because acceleration is always positive for distance calculation

D) Because final position is always greater than initial position

Q10. Physics Path →

Distance always counts the total path length positively, while displacement is the net change in position that can cancel out when motion reverses.

So, for oscillatory motion, repeated forward and backward travel increases total distance, but displacement only reflects the difference between final and initial positions.

Answer: (B) Because distance accumulates path length positively regardless of direction, whereas signed displacement accounts for directional reversals where backward motion cancels forward position change

B. Motion quantities

Q11. A particle moves along a straight line, shifting its position from an initial coordinate $x_1 = -4$ m to a final coordinate $x_2 = +6$ m. The displacement of the particle is:

A) $+2$ m B) $+10$ m C) -10 m D) $+6$ m

Q11. Physics Path →

Displacement is the difference between final and initial position coordinates.

$$\Delta x = x_2 - x_1 = (+6) - (-4) = +10 \text{ m}$$

Answer: (B) +10 m

Q12. An object moves along the x-axis such that its position changes from $x_1 = 2$ m to $x_2 = 14$ m over a time interval $\Delta t = 3$ s. Its average velocity is:

A) 3 m/s B) 4 m/s C) 5 m/s D) 6 m/s

Q12. Physics Path →

Average velocity is displacement ÷ time interval.

$$\Delta x = x_2 - x_1 = 14 - 2 = 12 \text{ m}$$

$$v_{avg} = \frac{\Delta x}{\Delta t} = \frac{12}{3} = 4 \text{ m/s}$$

Answer: (B) 4 m/s

Q13. A runner covers a total path length of 150 m in a total elapsed time of 25 s. The average speed of the runner is:

A) 4 m/s B) 5 m/s C) 6 m/s D) 7.5 m/s

Q13. Physics Path →

Average speed is total distance ÷ total time.

$$\bar{v} = \frac{\text{distance}}{\text{time}} = \frac{150}{25} = 6\ \text{m/s}$$

Answer: (C) 6 m/s

Q14. The position of a particle moving along a straight line is given by $x(t) = 2t^3 - 5t + 3$ (in SI units). What is its instantaneous velocity at $t = 2$ s?

A) 7 m/s B) 12 m/s C) 19 m/s D) 24 m/s

Q14. Physics Path →

Instantaneous velocity is the derivative of position with respect to time.

$$v(t) = \frac{dx}{dt} = \frac{d}{dt}(2t^3 - 5t + 3) = 6t^2 - 5$$

At $t = 2$ s:

$$v(2) = 6(2^2) - 5 = 24 - 5 = 19\ \text{m/s}$$

Answer: (C) 19 m/s

Q15. A particle starts at $x = 0$, moves along the x-axis to $x = +8$ m, and then turns around to stop at $x = +3$ m. What is the

ratio of the total distance travelled to the magnitude of its net displacement?

A) $3:1$ B) $13:3$ C) $8:3$ D) $11:5$

Q15. Physics Path →

Total distance is the sum of forward and backward travel.

- Forward: $0 \rightarrow +8$ m→ distance = 8 m
- Backward: $+8 \rightarrow +3$ m→ distance = 5 m

$$\text{Total distance} = 8 + 5 = 13 \text{ m}$$

Net displacement:

$$\Delta x = x_f - x_i = (+3) - 0 = +3 \text{ m}$$

Ratio:

$$\frac{\text{Distance}}{|\,\Delta x\,|} = \frac{13}{3}$$

Answer: (B) 13:3

Q16. During a specific time interval, an object moves along a straight line *without any directional reversal*. Which of the following relations strictly holds between its average speed and the magnitude of its average velocity?

A) Average speed < Magnitude of average velocity

B) Average speed = Magnitude of average velocity

C) Average speed > Magnitude of average velocity

D) Average speed can be zero while average velocity is non-zero

Q16. Physics Path →

When motion occurs along a straight line without reversal, the path length equals the magnitude of displacement.

- Average speed = total distance ÷ total time
- Magnitude of average velocity = $|\Delta x|/\Delta t$

Since distance = $|\Delta x|$ in this case, both values are identical.

Answer: (B) Average speed = Magnitude of average velocity

Q17. The velocity of a moving object increases uniformly from $u = 4$ m/s at $t_1 = 1$ s to $v = 16$ m/s at $t_2 = 4$ s. The average acceleration over this time interval is:

A) 3 m/s^2 B) 4 m/s^2 C) 5 m/s^2 D) 6 m/s^2

Q17. Physics Path →

Average acceleration is the change in velocity divided by the change in time.

$$a_{avg} = \frac{v - u}{t_2 - t_1}$$

Substitute values:

$$a_{avg} = \frac{16 - 4}{4 - 1} = \frac{12}{3} = 4 \text{ m/s}^2$$

Answer: (B) 4 m/s^2

Q18. The velocity of a particle is given as a function of time by $v(t) = 3t^2 - 2t + 4$. What is its instantaneous acceleration at $t = 3$ s?

A) $12\ \text{m/s}^2$ B) $14\ \text{m/s}^2$ C) $16\ \text{m/s}^2$ D) $18\ \text{m/s}^2$

Q18. Physics Path →

Instantaneous acceleration is the derivative of velocity with respect to time.

$$a(t) = \frac{dv}{dt} = \frac{d}{dt}(3t^2 - 2t + 4) = 6t - 2$$

At $t = 3$ s:

$$a(3) = 6(3) - 2 = 18 - 2 = 16\ \text{m/s}^2$$

Answer: (C) 16 m/s²

Q19. Which of the following statements concerning speed and instantaneous velocity is correct?

A) The magnitude of instantaneous velocity is always greater than speed.

B) Speed can be negative if an object moves in the negative coordinate direction.

C) Instantaneous speed is equal to the magnitude of instantaneous velocity.

D) A particle moving with constant speed must have zero acceleration.

Q19. Physics Path →

Let's carefully analyze each option:

(A) Incorrect → The magnitude of instantaneous velocity is equal to instantaneous speed, not always greater.

(B) Incorrect → Speed is a scalar and cannot be negative; only velocity can be negative depending on direction.

(C) Correct → By definition, instantaneous speed = | v |, the magnitude of instantaneous velocity.

(D) Incorrect → Constant speed does not imply zero acceleration; acceleration can change direction while maintaining constant speed (e.g., uniform circular motion).

Answer: (C) Instantaneous speed is equal to the magnitude of instantaneous velocity.

Q20.A particle moves along a semi-circular path of radius R from point $A(-R, 0)$ to point $B(R, 0)$ in a time interval t without reversing direction along the arc. The ratio of its average speed to the magnitude of its average velocity is:

A) $\frac{\pi}{2}$ B) $\frac{2}{\pi}$ C) π D) 1

Q20. Physics Path →

We compare average speed and average velocity:

- Average speed = total path length ÷ time Path length = semicircle arc = πR. So, $\bar{v}_{speed} = \frac{\pi R}{t}$.
- Magnitude of average velocity = straight-line displacement ÷ time Displacement = chord length from A(-R,0) to B(R,0) = $2R$. So, | $\bar{v}_{velocity}$ |= $\frac{2R}{t}$.
- Ratio:

$$\frac{\bar{v}_{speed}}{|\,\bar{v}_{velocity}\,|} = \frac{\pi R/t}{2R/t} = \frac{\pi}{2}$$

Answer: (A) $\pi/2$

C. Calculus and graph-linked relations

Q21. The velocity of a particle moving along the x-axis is given by $v(t) = (4t - 2)$ m/s. The displacement of the particle from $t = 1$ s to $t = 3$ s is:

A) 6 m B) 8 m C) 12 m D) 16 m

Q21. Physics Path →

Displacement is obtained by integrating velocity over time.

$$s = \int_{t=1}^{3} v\,(t)\,dt = \int_{1}^{3} (\,4t - 2)\,dt$$

$$= [2t^2 - 2t]_1^3 = (18 - 6) - (2 - 2) = 12\text{ m}$$

Answer: (C) 12 m

Q22.A particle starts with an initial velocity of $u = 3$ m/s at $t = 0$. Its acceleration as a function of time is given by $a(t) = (6t + 2)$ m/s^2. What is its velocity at $t = 2$ s?

A) 11 m/s B) 15 m/s C) 19 m/s D) 22 m/s

Q22. Physics Path →

Velocity is obtained by integrating acceleration over time and adding the initial velocity.

$$v(t) = u + \int_0^t a\,(t)\,dt$$

$$= 3 + \int_0^2 (6t + 2)\,dt = 3 + [3t^2 + 2t]_0^2 = 3 + (12 + 4) = 19\ \text{m/s}$$

Answer: (C) 19 m/s

Q23. The acceleration of a particle moving along the x-axis is given by $a(x) = 2x$ m/s^2. If the particle starts from rest at the origin ($x = 0$, $v = 0$), its speed when it reaches $x = 3$ m is:

A) $2\sqrt{3}$ m/s B) $3\sqrt{2}$ m/s C) 6 m/s D) 3 m/s

Q23. Physics Path →

Here acceleration depends on position, so use the relation between acceleration and velocity:

$$a = v\frac{dv}{dx}$$

Given $a(x) = 2x$:

$$v\frac{dv}{dx} = 2x$$

Integrate from $x = 0, v = 0$to $x = 3, v =$?:

$$\int_0^v v\ dv = \int_0^3 2\,x\,dx$$

$$\frac{v^2}{2} = x^2\ |_0^3 = 9$$

$$v^2 = 18\ \Rightarrow\ v = 3\sqrt{2}\ \text{m/s}$$

Answer: (B) $3\sqrt{2}$ m/s

Q24. A particle is in uniform motion along a straight line with a constant velocity of $v = +5$ m/s and starts from an initial position $x_0 = -2$ m. What is its position at $t = 4$ s?

A) $+18$ m B) $+20$ m C) $+22$ m D) $+12$ m

Q24. Physics Path →

For uniform motion with constant velocity, position is given by

$$x(t) = x_0 + vt$$

Substitute values:

$$x(4) = -2 + (5)(4) = -2 + 20 = +18\,\text{m}$$

Answer: (A) +18 m

Q25. In a velocity-time graph, the displacement of a particle over a given time interval $[t_1, t_2]$ is represented by:

A) The slope of the tangent at that instant

B) The signed area under the velocity-time curve

C) The total path length traversed

D) The product of final velocity and total time

Q25. Physics Path →

On a velocity–time graph, displacement is represented by the signed area under the curve between t_1 and t_2.

Answer: (B) The signed area under the velocity-time curve

Q26. A particle moves with position-dependent acceleration $a(x) = kx$, where k is a positive constant. If the particle accelerates from rest at $x = 0$ to a velocity v_1 at position x_1, what will be its velocity v_2 at position $x_2 = 2x_1$, starting from rest?

A) $v_2 = \sqrt{2}v_1$

B) $v_2 = 2v_1$

C) $v_2 = 4v_1$

D) $v_2 = 2\sqrt{2}v_1$

Q26. Physics Path →

Acceleration depends on position, so use $a = v\frac{dv}{dx}$.

$$a(x) = kx \Rightarrow v\frac{dv}{dx} = kx$$

Integrate from $x = 0, v = 0$to $x = x_1, v = v_1$:

$$\frac{v_1^2}{2} = \frac{kx_1^2}{2} \Rightarrow v_1^2 = kx_1^2$$

At $x_2 = 2x_1$:

$$\frac{v_2^2}{2} = \frac{k(2x_1)^2}{2} = 2kx_1^2$$

$$v_2^2 = 4kx_1^2 = 4v_1^2 \Rightarrow v_2 = 2v_1$$

Answer: (B) $v_2 = 2v_1$

Q27. Two particles, A and B, undergo uniform motion along parallel straight lines with constant velocities v_A and v_B respectively, starting from the same origin ($x_0 = 0$). If $v_A = 3v_B$, what is the ratio of their displacements $\Delta x_A : \Delta x_B$ after the same time interval t?

A) $1:3$ B) $3:1$ C) $9:1$ D) $1:9$

Q27. Physics Path →

For uniform motion, displacement after time $t$is $\Delta x = vt$.

- Particle A: $\Delta x_A = v_A t = 3v_B t$
- Particle B: $\Delta x_B = v_B t$

So,

$$\Delta x_A : \Delta x_B = 3v_B t : v_B t = 3:1$$

Answer: (B) 3:1

Q28. The acceleration-time graph of a particle shows that the signed area enclosed between $t = 0$ and $t = t_1$ is A_1, and between $t = t_1$ and $t = 2t_1$ is $A_2 = -A_1$. If the particle starts from rest at $t = 0$, what is its velocity at $t = 2t_1$?

A) $2A_1$ B) A_1 C) Zero D) $-A_1$

Q28. Physics Path →

Velocity change is given by the area under the acceleration–time graph.

- From $t = 0$to $t = t_1$, area = A_1.
- From $t = t_1$to $t = 2t_1$, area = $A_2 = -A_1$.

Net change in velocity = $A_1 + (-A_1) = 0$. Since the particle starts from rest, final velocity at $t = 2t_1$is zero.

Answer: (C) Zero

Q29. Which of the following correctly expresses acceleration as a function of position using the chain rule in one-dimensional kinematics?

A) $a = \frac{dx}{dt}$

B) $a = v\frac{dv}{dx}$

C) $a = x\frac{dv}{dt}$

D) $a = \frac{d^2x}{dt \cdot dx}$

Q29. Physics Path →

Using the chain rule in 1D kinematics:

$$a = \frac{dv}{dt} = \frac{dv}{dx} \cdot \frac{dx}{dt} = v\frac{dv}{dx}$$

This expresses acceleration as a function of position.

Answer: (B) $a = v\frac{dv}{dx}$

Q30. A particle moves back and forth along a straight line such that its velocity function $v(t)$ changes sign during the time interval $[0, T]$. How is the total distance travelled by the particle related to its velocity function?

A) $\int_0^T v\,(t)\,dt$

B) $\left|\int_0^T v\,(t)\,dt\right|$

C) $\int_0^T |\,v(t)|\,dt$

D) $\int_0^T v^2\,(t)\,dt$

Q30. Physics Path →

- Displacement is given by $\int_0^T v\,(t)\,dt$.
- But distance travelled must count all motion positively, even when velocity changes sign.

- Therefore, the correct expression is:

$$\text{Distance} = \int_0^T |\, v(t) \,|\; dt$$

Answer: (C) $\int_0^T |\, v(t) \,|\; dt$

D. Constant-acceleration equations

Q31. A particle starts with an initial velocity of 2 m/s and moves along a straight line with a constant acceleration of 3 m/s^2. What is its velocity after 4 s?

A) 10 m/s B) 12 m/s C) 14 m/s D) 16 m/s

Q31. Physics Path →

For constant acceleration, velocity evolves as

$$v = u + at$$

Substitute values:

$$v = 2 + (3)(4) = 2 + 12 = 14 \text{ m/s}$$

Answer: (C) 14 m/s

Q32. An object moves in a straight line under constant acceleration, starting from rest ($u = 0$) with an acceleration of 4 m/s^2. The displacement of the object in 5 s is:

A) 25 m B) 50 m C) 75 m D) 100 m

Q32. Physics Path →

For constant acceleration starting from rest, displacement is

$$s = ut + \frac{1}{2}at^2$$

Here $u = 0$, $a = 4\ \text{m/s}^2$, $t = 5\ \text{s}$:

$$s = 0 + \frac{1}{2}(4)(25) = 50\ \text{m}$$

Answer: (B) 50 m

Q33. A car travelling with an initial velocity of 5 m/s accelerates uniformly at 2 m/s^2 over a straight distance of 12 m. What is its final velocity?

A) 7 m/s B) 9 m/s C) 11 m/s D) 13 m/s

Q33. Physics Path →

For constant acceleration, use the kinematic relation:

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

Substitute values:

$$v^2 = (5)^2 + 2(2)(12) = 25 + 48 = 73$$

$$v = \sqrt{73} \approx 8.54\ \text{m/s}$$

Closest option is **9 m/s**.

Answer: (B) 9 m/s

Q34. A body starts from rest and moves with a uniform acceleration of 2 m/s^2. The displacement of the body during the 5^{th} second of its motion is:

A) 9 m B) 10 m C) 11 m D) 25 m

Q34. Physics Path →

Displacement during the n^{th}second under uniform acceleration is given by:

$$s_n = u + \frac{1}{2}a(2n-1)$$

Here $u = 0$, $a = 2$ m/s^2, $n = 5$:

$$s_5 = 0 + \frac{1}{2}(2)(9) = 9 \text{ m}$$

Answer: (A) 9 m

Q35. A particle starts from rest and moves with constant acceleration along a straight line. What is the ratio of the distance travelled in the first 2 seconds to the distance travelled in the first 4 seconds?

A) $1:2$ B) $1:4$ C) $1:8$ D) $2:1$

Q35. Physics Path →

For constant acceleration starting from rest, displacement in time $t$is

$$s = \frac{1}{2}at^2$$

- In first 2 seconds:

$$s_2 = \frac{1}{2}a(2^2) = 2a$$

- In first 4 seconds:

$$s_4 = \frac{1}{2}a(4^2) = 8a$$

So,

$$s_2 : s_4 = 2a : 8a = 1 : 4$$

Answer: (B) 1:4

Q36. An object moves with constant acceleration from rest. If its cumulative displacement in the first n seconds is S_n and its displacement during the n^{th} second is s_n, what is the exact ratio S_n/s_n for $n = 3$?

A) $5:3$ B) $9:5$ C) $3:5$ D) $9:1$

Q36. Physics Path →

We need the ratio of **cumulative displacement** in the first $n$seconds (S_n) to the **displacement during the n^{th}second** (s_n).

- Formula for cumulative displacement:

$$S_n = \frac{1}{2}an^2$$

- Formula for displacement in the n^{th}second:

$$s_n = \frac{1}{2}a(2n - 1)$$

Now for $n = 3$:

$$S_3 = \frac{1}{2}a(3^2) = \frac{9}{2}a$$

$$s_3 = \frac{1}{2}a(2 \cdot 3 - 1) = \frac{5}{2}a$$

So,

$$\frac{S_3}{s_3} = \frac{\frac{9}{2}a}{\frac{5}{2}a} = \frac{9}{5}$$

Answer: (B) 9:5

Q37. Under a condition of constant acceleration, a car's velocity changes from u to v over a time interval t. If the average velocity over this interval is expressed as $\bar{v} = \frac{u+v}{2}$, how does this mean velocity compare to the instantaneous velocity exactly at the midpoint of the time interval ($t/2$)?

A) $\bar{v}$ is greater than the midpoint instantaneous velocity

B) $\bar{v}$ is less than the midpoint instantaneous velocity

C) $\bar{v}$ is exactly equal to the midpoint instantaneous velocity

D) $\bar{v}$ is independent of the midpoint instantaneous velocity

Q37. Physics Path →

For constant acceleration, velocity at any time is

$$v(t) = u + at$$

At midpoint $t/2$:

$$v\left(\frac{t}{2}\right) = u + a\frac{t}{2}$$

But since $v = u + at$, we can write $a = \frac{v-u}{t}$.

So,

$$v\left(\frac{t}{2}\right) = u + \frac{v-u}{t} \cdot \frac{t}{2} = u + \frac{v-u}{2} = \frac{u+v}{2}$$

This is exactly the **average velocity** over the interval.

Answer: (C) $\bar{v}$ is exactly equal to the midpoint instantaneous velocity

Q38. A train decelerates uniformly under a constant braking acceleration a until it comes to a stop. If its final velocity is known to be zero, its stopping displacement expressed in terms of final velocity v (which is 0), initial velocity u, and time t elapsed before stopping is given by $s = ut - \frac{1}{2}at^2$. If u is doubled while a remains constant, by what factor does the stopping time change?

A) Halved B) Unchanged C) Doubled D) Quadrupled

Q38. Physics Path →

We know the stopping condition:

$$v = u - at = 0 \Rightarrow t = \frac{u}{a}$$

So the stopping time depends directly on the initial velocity $u$and inversely on acceleration a.

- If $u$is doubled while $a$remains constant:

$$t' = \frac{2u}{a} = 2 \cdot \frac{u}{a} = 2t$$

Thus, the stopping time **doubles.**

Answer: (C) Doubled

Q39. Which of the following expressions represents the displacement of a uniformly accelerated body in terms of its initial velocity u, final velocity v, and elapsed time t?

A) $s = ut + \frac{1}{2}at^2$

B) $s = \frac{(u+v)t}{2}$

C) $s = vt - \frac{1}{2}at^2$

D) $s = \frac{v^2-u^2}{2a}$

Q39. Physics Path →

We want displacement expressed in terms of **initial velocity u, final velocity v, and elapsed time t.**

- The average velocity under constant acceleration is:

$$\bar{v} = \frac{u+v}{2}$$

- Displacement is average velocity × time:

$$s = \bar{v} \cdot t = \frac{u+v}{2} \cdot t$$

Answer: (B) $s = \frac{(u+v)t}{2}$

Q40. A particle starts from rest and moves along a straight line with constant acceleration. The ratio of displacements during the consecutive 1^{st}, 2^{nd}, and 3^{rd} seconds of its motion is:

A) $1:2:3$

B) $1:4:9$

C) $1:3:5$

D) $1:\sqrt{2}:\sqrt{3}$

Q40. Physics Path →

Displacement during the n^{th}second under constant acceleration (starting from rest) is:

$$s_n = \frac{1}{2}a(2n-1)$$

- For $n = 1$:

$$s_1 = \frac{1}{2}a(1) = \frac{a}{2}$$

- For $n = 2$:

$$s_2 = \frac{1}{2}a(3) = \frac{3a}{2}$$

- For $n = 3$:

$$s_3 = \frac{1}{2}a(5) = \frac{5a}{2}$$

So the ratio is:

$$s_1 : s_2 : s_3 = \frac{a}{2} : \frac{3a}{2} : \frac{5a}{2} = 1 : 3 : 5$$

E. Ratios, averages and stopping

Q41. A car travels the first half of a straight journey with a constant speed of 20 m/s and the second half with a constant speed of 30 m/s over equal distances. Its average speed for the entire journey is:

A) 24 m/s B) 25 m/s C) 26.5 m/s D) 22.5 m/s

Q41. Physics Path →

The journey is split into **equal distances** at two speeds. For equal distances, the average speed is the **harmonic mean** of the two speeds:

$$v_{avg} = \frac{2v_1v_2}{v_1 + v_2}$$

Substitute:

$$v_{avg} = \frac{2(20)(30)}{20 + 30} = \frac{1200}{50} = 24 \text{ m/s}$$

Think: Equal distances → harmonic mean of speeds.

Answer: (A) 24 m/s

Q42. A vehicle moves for two equal time intervals, travelling at speeds of 40 m/s in the first interval and 60 m/s in the second interval. Its average speed over the total time is

A) 48 m/s B) 50 m/s C) 52 m/s D) 55 m/s

Q42. Physics Path →

Here the vehicle moves with **equal time intervals** at two speeds. For equal times, the average speed is the **arithmetic mean** of the two speeds:

$$v_{avg} = \frac{v_1 + v_2}{2}$$

Substitute:

$$v_{avg} = \frac{40 + 60}{2} = 50 \text{ m/s}$$

Think: Equal times → arithmetic mean of speeds.

Answer: (B) 50 m/s

Q43. A car moving along a straight road with an initial velocity of 20 m/s applies brakes, creating a constant opposing acceleration (retardation) of 5 m/s^2. The time taken by the car to come to a complete stop is:

A) 2 s B) 3 s C) 4 s D) 5 s

Q43. Physics Path →

The car starts with velocity $u = 20$ m/sand decelerates at $a = 5$ m/s^2. Stopping condition: $v = u - at = 0$.

$$t = \frac{u}{a} = \frac{20}{5} = 4 \text{ s}$$

Think: Stopping time = initial velocity ÷ retardation.

Answer: (C) 4 s

Q44. A train is travelling at 30 m/s when brakes are applied, producing a uniform deceleration of 5 m/s^2. What is the stopping displacement of the train before it comes to rest

A) 45 m B) 60 m C) 90 m D) 180 m

Q44. Physics Path →

Stopping displacement under constant deceleration is found using

$$s = \frac{u^2 - v^2}{2a}$$

Here $u = 30$ m/s, $v = 0$, $a = 5$ m/s^2:

$$s = \frac{30^2 - 0}{2 \cdot 5} = \frac{900}{10} = 90 \text{ m}$$

Think: Use $s = \frac{u^2 - v^2}{2a}$ when final velocity is zero.

Answer: (C) 90 m

Q45. An object starts from rest and moves with constant acceleration along a straight line. What is the exact ratio of its cumulative displacement in the first 4 seconds (S_4) to its displacement during the 4^{th} second (s_4)?

A) $16:7$ B) $4:3$ C) $8:5$ D) $16:9$

Q45. Physics Path →

From rest under constant acceleration:

- Cumulative displacement in first $n$seconds:

$$S_n = \frac{1}{2}an^2$$

- Displacement in the n^{th}second:

$$s_n = \frac{1}{2}a(2n - 1)$$

For $n = 4$:

$$S_4 = \frac{1}{2}a(16) = 8a,\ s_4 = \frac{1}{2}a(7) = \frac{7}{2}a$$

So,

$$\frac{S_4}{s_4} = \frac{8a}{\frac{7}{2}a} = \frac{16}{7}$$

Think: Use ratio form $S_n/s_n = \frac{n^2}{2n-1}$

Answer: (A) 16:7

Q46. A particle moves 15 m forward along a straight line, reverses its direction, and moves 8 m backward before coming to rest. The total distance travelled by the particle is:

A) 7 m B) 15 m C) 23 m D) 30

Q46. Physics Path →

The particle first moves **forward 15 m**, then **backward 8 m**.

- **Distance** is the total path length, so both segments add positively:

$$\text{Distance} = 15 + 8 = 23 \text{ m}$$

Think: Distance = sum of magnitudes of each segment (MSL-034).

Answer: (C) 23 m

Q47. A particle starts from rest and moves with constant acceleration. If the elapsed time from the start is tripled ($t_2 = 3t_1$), by what factor does its displacement from the start increase?

A) 3 times B) 6 times C) 9 times D) 27 times

Q47. Physics Path →

From rest under constant acceleration:

$$s = \frac{1}{2}at^2 \Rightarrow s \propto t^2$$

If time is tripled ($t_2 = 3t_1$):

$$\frac{s_2}{s_1} = \left(\frac{t_2}{t_1}\right)^2 = (3)^2 = 9$$

So displacement increases **9 times**.

Think: From rest → displacement grows with square of time (MSL-021, MSL-024).

Answer: (C) 9 times

Q48. Starting from rest under uniform acceleration, the velocity of a particle is measured at two positive time instants. If the time ratio is $t_2/t_1 = 4$, the corresponding velocity ratio v_2/v_1 is:

A) 2 B) 4 C) 8 D) 16

Q48. Physics Path →

From rest under constant acceleration:

$$v = at \Rightarrow v \propto t$$

So the velocity ratio equals the time ratio:

$$\frac{v_2}{v_1} = \frac{t_2}{t_1} = 4$$

Think: From rest → velocity grows linearly with time (MSL-021, MSL-025).

Answer: (B) 4

Q49. A particle starts from rest and moves with constant acceleration. If its displacement increases by a factor of 9, by what factor does the magnitude of its final velocity increase?

A) 3 times B) 9 times C) 81 times D) $\sqrt{3}$ times

Q49. Physics Path →

From rest under constant acceleration:

- Displacement relation:

$$s = \frac{1}{2}at^2$$

so $s \propto t^2$.

- Velocity relation:

$$v = at$$

so $v \propto t$.

Thus,

$$s \propto v^2 \Rightarrow \frac{s_2}{s_1} = \left(\frac{v_2}{v_1}\right)^2$$

If displacement increases by a factor of 9:

$$\frac{s_2}{s_1} = 9 \Rightarrow \left(\frac{v_2}{v_1}\right)^2 = 9$$

$$\frac{v_2}{v_1} = 3$$

Think: From rest → use $v^2 = 2as$(MSL-021, MSL-026).

Answer: (A) 3 times

Q50. Under the same constant acceleration, the velocity changes of a particle over two intervals starting from rest are compared. If the time intervals are in the ratio $t_1 : t_2 = 2 : 5$, what is the ratio of their velocity changes $\Delta v_1 : \Delta v_2$?

A) $4 : 25$ B) $2 : 5$ C) $\sqrt{2} : \sqrt{5}$ D) $25 : 4$

Q50. Physics Path →

For constant acceleration:

$$\Delta v = at$$

So the change in velocity is directly proportional to the elapsed time.

Given $t_1 : t_2 = 2 : 5$:

$$\Delta v_1 : \Delta v_2 = t_1 : t_2 = 2 : 5$$

Think: Under constant acceleration, velocity change grows linearly with time (MSL-027).

Answer: (B) 2:5

Q51. For an object starting from rest with constant acceleration, the ratio of cumulative displacement in the first n seconds to the displacement during the n^{th} second is given by $S_n / s_n = n^2/(2n - 1)$. As n becomes very large ($n \to \infty$), this ratio approaches:

A) $1 : 2$ B) Linear growth with n $(n/2)$

C) Constant value of 1 D) Zero

Q51. Physics Path →

For motion from rest under constant acceleration:

$$\frac{S_n}{s_n} = \frac{n^2}{2n-1}$$

As $n \to \infty$:

- Numerator grows as n^2.
- Denominator grows as $2n$. So,

$$\frac{S_n}{s_n} \approx \frac{n^2}{2n} = \frac{n}{2}$$

This means the ratio grows **linearly with** n, approaching $\frac{n}{2}$.

Think: Use limiting behavior — quadratic vs. linear growth (MSL-030).

Answer: (B) Linear growth with n (n/2)

Q52. A particle moves along the x-axis such that its instantaneous velocity is zero at a particular instant t_0. Which of the following conditions is both necessary and sufficient to conclude that the particle experiences a directional reversal at t_0?

A) Acceleration must be zero at t_0

B) Velocity must change sign across the instant t_0

C) Position x must be maximum at t_0

D) Speed must be maximum at t_0

Q52. Physics Path →

At A directional reversal occurs when the particle changes its direction of motion. For rectilinear motion, this requires the velocity to change sign across t_0,

Having v(t) = 0 alone does not establish a reversal. For example, a particle may momentarily have zero velocity without changing direction.

Think: Turning point requires velocity sign change, not just $v = 0$(MSL-033).

Answer: (B) Velocity must change sign across the instant t_0

Q53. A motorist travels between two towns, covering the first half of the distance at v_1 and the second half at v_2. Why must the average speed be calculated using the harmonic mean rather than the arithmetic mean?

A) Because equal times are spent traveling at each speed

B) Because more time is spent traveling at the slower speed over equal distances

C) Because acceleration varies non-linearly across distance

D) Because distance is a vector quantity requiring directional averaging

Q53. Physics Path →

When equal **distances** are covered at two speeds, the time taken is different for each leg. More time is spent at the **slower speed**, so the average speed is weighted toward it.

That's why the correct average speed is the **harmonic mean:**

$$\bar{v} = \frac{2v_1v_2}{v_1 + v_2}$$

Think: Equal distances → slower speed dominates time, so use harmonic mean (MSL-028).

Answer: (B) Because more time is spent traveling at the slower speed over equal distances

Q54. A ball is projected vertically upward and momentarily comes to rest at its highest point. What is the physical state of the ball's acceleration at this turning point?

A) Acceleration is zero because velocity is zero

B) Acceleration is directed upward with magnitude g

C) Acceleration is constant and directed downward with magnitude g

D) Acceleration changes direction from upward to downward at that instant

Q54. Physics Path →

At the highest point, the ball's **velocity becomes zero momentarily**, but the acceleration due to gravity remains constant. Gravity always acts downward with magnitude g, independent of the velocity state.

So at the turning point:

$$a = -g \text{ (downward, constant)}$$

Think: At a vertical turning point, $v = 0$but $a = -g$is nonzero (MSL-035, MSL-033).

Answer: (C) Acceleration is constant and directed downward with magnitude g

Q55. When an object undergoes multiple directional reversals during its rectilinear motion, how must the total distance travelled be correctly evaluated?

A) By taking the magnitude of the net final displacement vector

B) By summing the magnitudes of each individual displacement segment between reversals

C) By integrating the velocity function without absolute value signs

D) By subtracting the backward displacement segments from the forward displacement segments

Q55. Physics Path →

When motion involves **multiple directional reversals**, the **net displacement** alone does not capture the total path length.

- **Distance** must be calculated as the **sum of magnitudes of each displacement segment** between reversals:

$$\text{Distance} = |s_1| + |s_2| + |s_3| + \cdots$$

This ensures that backward motion contributes positively to the total distance, rather than canceling forward motion.

Think: Use rule for distance after reversal (MSL-034).

Answer: (B) By summing the magnitudes of each individual displacement segment between reversals

F. Vertical motion under gravity

Q56. A ball is thrown vertically upward with an initial velocity of $+25$ m/s from the ground. Using the upward-positive convention where $a = -g$ and $g = 10$ m/s^2, what is its velocity after 3 s?

A) $+5$ m/s B) -5 m/s C) $+10$ m/s D) -15 m/s

Q56. Physics Path →

We use the **first equation of motion** under constant acceleration (MSL-015):

$$v = u + at$$

Here:

- $u = +25$ m/s(upward, positive)
- $a = -g = -10$ m/s^2(downward)
- $t = 3$ s

$$v = 25 + (-10)(3) = 25 - 30 = -5 \text{ m/s}$$

So after 3 seconds, the ball's velocity is **downward with magnitude 5 m/s.**

Answer: (B) -5 m/s

Q57. An object is projected vertically upward with an initial speed of 30 m/s. Taking $g = 10$ m/s^2 and upward as positive, what is its vertical displacement $(y - y_0)$ after 4 s?

A) $+40$ m B) $+120$ m C) $+80$ m D) $+20$ m

Q57. Physics Path →

We use the **vertical displacement formula** (MSL-037):

$$y - y_0 = ut - \frac{1}{2}gt^2$$

Here:

- $u = +30$ m/s(upward, positive)
- $g = 10$ m/s^2
- $t = 4$ s

$$y - y_0 = (30)(4) - \frac{1}{2}(10)(4^2)$$
$$= 120 - 80 = +40 \text{ m}$$

So the ball is **40 m above the ground relative to launch point** after 4 seconds.

Answer: (A) +40 m

Q58. A rocket or stone is projected vertically upward with an initial speed of 50 m/s. Neglecting air resistance and taking $g = 10$ m/s^2, the maximum rise H above the launch point is:

A) 100 m B) 125 m C) 250 m D) 500 m

Q58. Physics Path →

We use the **maximum rise formula** (MSL-040):

$$H = \frac{u^2}{2g}$$

Here:

- $u = 50$ m/s
- $g = 10$ m/s^2

$$H = \frac{(50)^2}{2 \cdot 10} = \frac{2500}{20} = 125 \text{ m}$$

So the ball rises **125 m above the launch point**.

Answer: (B) 125 m

Q59.A heavy package is dropped from rest from a bridge and strikes the water below after 4 s. Taking $g = 10$ m/s^2 and neglecting air resistance, the impact speed with which it hits the water is:

A) 20 m/s B) 30 m/s C) 40 m/s D) 80 m/s

Q59. Physics Path →

We use the **first equation of motion** (MSL-015):

$$v = u + at$$

Here:

- $u = 0$(dropped from rest)
- $a = g = 10$ m/s^2(downward)
- $t = 4$ s

$$v = 0 + (10)(4) = 40 \text{ m/s}$$

So the package strikes the water with an **impact speed of 40 m/s**.

Answer: (C) 40 m/s

Q60. A stone is thrown vertically upward with an initial speed of 20 m/s from the top of a tower that is 25 m high above the ground. Taking $g = 10$ m/s^2, the total time taken by the stone to reach the ground ($y = 0$) is:

A) 3 s B) 4 s C) 5 s D) 6 s

Q60. Physics Path →

We use the **vertical displacement equation** (MSL-037):

$$y - y_0 = ut - \frac{1}{2}gt^2$$

Here:

- Launch point: $y_0 = 25$ m(tower height)
- $u = +20$ m/s(upward, positive)
- $g = 10$ m/s^2
- Ground: $y = 0$

So,

$$0 - 25 = (20)(t) - \frac{1}{2}(10)(t^2)$$

$$-25 = 20t - 5t^2$$

$$5t^2 - 20t - 25 = 0$$

$$t^2 - 4t - 5 = 0$$

Factorizing:

$$(t - 5)(t + 1) = 0$$
$t = 5$ s (physical solution, positive time)

So the stone reaches the ground after **5 seconds**.

Answer: (C) 5 s

Q61. An ideal vertical projectile is thrown from the ground and returns to the same level after a total flight time of $T = 6$ s. Using $g = 10$ m/s^2, what is the maximum rise H calculated using the same-level flight time relation $H = \frac{gT^2}{8}$?

A) 30 m B) 45 m C) 60 m D) 90 m

Q61. Physics Path →

The projectile returns to the same level after flight time $T = 6$ s. For same-level vertical motion, the maximum rise is given by the relation:

$$H = \frac{gT^2}{8}$$

Substitute $g = 10$ m/s^2, $T = 6$ s:

$$H = \frac{10 \cdot (6^2)}{8} = \frac{10 \cdot 36}{8} = \frac{360}{8} = 45 \text{ m}$$

Think: Same-level flight time relation applies only when launch and landing heights are equal.

Answer: (B) 45 m

Q62. If the initial vertical launch velocity u of a projectile is tripled ($u_2 = 3u_1$), by what factor does its maximum rise H above the launh point increase?

A) 3 times B) 6 times C) 9 times D) 27 times

Q62. Physics Path →

Maximum rise is given by $H = \frac{u^2}{2g}$. Since $H \propto u^2$, tripling the launch velocity multiplies the height by $3^2 = 9$.

$$H_2 = \frac{(3u)^2}{2g} = 9 \cdot \frac{u^2}{2g} = 9H_1$$

Think: Rise depends on the **square** of velocity, not directly on velocity.

Answer: (C) 9 times

Q63. Two stones, P and Q, are projected vertically upward with initial speeds u and $2u$ respectively, and both return to their respective launch levels. What is the ratio of their return times to the launch level ($T_P : T_Q$)?

A) $1:2$ B) $1:4$ C) $2:1$ D) $4:1$

Q63. Physics Path →

Return time to the same level is given by $T = \frac{2u}{g}$. Since time is directly proportional to initial velocity, doubling the launch speed doubles the return time.

$$T_P = \frac{2u}{g},\ T_Q = \frac{2(2u)}{g} = \frac{4u}{g}$$

$$\therefore\ T_P : T_Q = \frac{2u}{g} : \frac{4u}{g} = 1:2$$

Think: Flight time scales linearly with initial velocity, not with its square.

Answer: (A) 1:2

Q64. An object is dropped from rest from a height h_1, hitting the ground with an impact speed v_1. If it is instead dropped from a new height $h_2 = 9h_1$, the ratio of the new impact speed v_2 to v_1 is:

A) $3:1$ B) $9:1$ C) $1:3$ D) $81:1$

Q64. Physics Path →

Impact speed for a drop from rest is given by

$$v = \sqrt{2gh}$$

So $v \propto \sqrt{h}$.

If $h_2 = 9h_1$:

$$\frac{v_2}{v_1} = \sqrt{\frac{h_2}{h_1}} = \sqrt{9} = 3$$

Thus, $v_2 : v_1 = 3:1$.

Think: Impact speed grows with the square root of height, not directly with height.

Answer: (A) 3:1

Q65 Two identical balls are thrown from the edge of a cliff of height h: ball A is thrown vertically upward with speed u, and ball B is thrown vertically downward with the same speed u. How do their impact speeds with the ground ($v_{A,\text{impact}}$ and $v_{B,\text{impact}}$) compare?

A) $v_{A,\text{impact}} > v_{B,\text{impact}}$ B) $v_{A,\text{impact}} < v_{B,\text{impact}}$

C) $v_{A,\text{impact}} = v_{B,\text{impact}}$ D) $v_{A,\text{impact}} = 2v_{B,\text{impact}}$

Q65. Physics Path →

Impact speed from a height $h$with initial vertical speed $u$is given by:

$$v_{\text{impact}} = \sqrt{u^2 + 2gh}$$

For ball A (upward) and ball B (downward), the launch speeds are both u. The formula depends only on the **magnitude** of initial speed and height drop, not the direction.

$$v_{A,\text{impact}} = v_{B,\text{impact}} = \sqrt{u^2 + 2gh}$$

Think: Launching upward or downward with the same speed from the same height gives identical impact speeds.

Answer: (C) $v_{A,\text{impact}} = v_{B,\text{impact}}$

Q66 A vertical projectile passes a point at height y above the ground at time t_1 during its ascent and at time t_2 during its descent. What is the ratio of its signed vertical velocities at these two instances ($v(t_1) : v(t_2)$)?

A) $1:1$ B) $t_1 : t_2$ C) $-1:1$ D) $\sqrt{t_1} : \sqrt{t_2}$

Q66. Physics Path →

At equal heights during ascent and descent, the projectile's **speed magnitudes are equal but directions are opposite**. Thus the signed velocities satisfy:

$$v(t_2) = -v(t_1)$$

So the ratio is:

$$v(t_1) : v(t_2) = -1 : 1$$

Think: Equal-height speed symmetry → same magnitude, opposite sign.

Answer: (C) $-1:1$

Q67. For a vertical projectile launched with initial speed u, the time taken to reach the highest point is $t_{\text{up}} = \frac{u}{g}$. If the launch speed u is halved, how does the time to the highest point change?

A) It is doubled

B) It is halved

C) It is quadrupled

D) It remains unchanged

Q67. Physics Path →

Time to highest point is given by

$$t_{\text{up}} = \frac{u}{g}$$

Since $t_{\text{up}} \propto u$, halving the launch speed directly halves the time to reach the highest point.

$$t'_{\text{up}} = \frac{u/2}{g} = \frac{1}{2} \cdot \frac{u}{g}$$

Think: Time to rise depends linearly on initial velocity, not on its square.

Answer: (B) It is halved

Q68. A stone is thrown straight up into the air. At the very highest point of its vertical trajectory, which of the following physical quantities is completely zero?

A) Acceleration B) Velocity

C) Both velocity and acceleration D) Force of gravity

Q68. Physics Path →

At the very highest point, the projectile's **velocity becomes zero** momentarily because it stops rising before descending. However, the **acceleration due to gravity remains constant** ($a = -g$), and the force of gravity is never zero.

So the only physical quantity that is completely zero at the top is **velocity.**

Think: At the turning point, $v = 0$ but $a = -g$is still acting downward.

Answer: (B) Velocity

Q69. A ball is thrown vertically upward from the ground and later falls back down, passing a window ledge twice (once going up, once coming down). Which of the following parameters is identical at both passages of the ledge?

A) Signed velocity vector

B) Displacement from launch point

C) Instantaneous speed directions differ

D) Time elapsed from launch

Q69. Physics Path →

When the ball passes the same height (the window ledge) during ascent and descent, its **displacement from the launch point** is identical both times. The signed velocity differs (upward vs. downward), the speed magnitudes are equal but not identical in sign, and the times elapsed are different.

So the identical parameter is the **displacement from launch point.**

Think: Equal-height symmetry → same displacement, opposite signed velocities, unequal times.

Answer: (B) Displacement from launch point

Q70. When formulating motion equations for a vertical projectile near Earth's surface using the standard upward-positive convention, why is the acceleration due to gravity substituted as $-g$ rather than $+g$?

A) Because gravity acts downward, opposing the chosen positive coordinate direction

B) Because speed must always decrease continuously during flight

C) Because the magnitude of gravity decreases with altitude

D) Because initial velocity is always positive

Q70. Physics Path →

In the upward-positive convention, gravity always acts downward. Since acceleration is defined relative to the chosen positive axis, the gravitational acceleration must be written as **−g** to reflect its opposite direction.

Think: The sign of acceleration depends on the coordinate choice, not on the magnitude of gravity.

Answer: (A) Because gravity acts downward, opposing the chosen positive coordinate direction

G. Relative motion

Q71. Two trains A and B are moving along parallel tracks in the same direction with velocities $v_A = +60$ km/h and $v_B = +40$ km/h respectively. The relative velocity of train A with respect to train B ($v_{A/B}$) is:

A) $+20$ km/h

B) -20 km/h

C) $+100$ km/h

D) -100 km/h

Q71. Physics Path →

Relative velocity is defined as:

$$v_{A/B} = v_A - v_B$$

Substitute values:

$$v_{A/B} = 60 - 40 = +20 \text{ km/h}$$

So train A appears to move forward at 20 km/h relative to train B.

Think: Relative velocity is always measured in the same frame and along the same axis.

Answer: (A) +20 km/h

Q72. In a one-dimensional reference frame, if the relative velocity of car P with respect to car Q is $v_{P/Q} = -15$ m/s, what is the relative velocity of car Q with respect to car P ($v_{Q/P}$)?

A) -15 m/s B) $+15$ m/s C) 0 m/s D) $+30$ m/s

Q72. Physics Path →

Relative velocity reverses sign when switching the reference frame:

$$v_{Q/P} = -v_{P/Q}$$

Given $v_{P/Q} = -15$ m/s:

$$v_{Q/P} = -(-15) = +15 \text{ m/s}$$

Think: Relative velocities are equal in magnitude but opposite in sign.

Answer: (B) +15 m/s

Q73. Two cars are moving towards each other along a straight road with speeds of $v_1 = 20$ m/s and $v_2 = 30$ m/s respectively. Their closing speed is:

A) 10 m/s B) 25 m/s

C) 50 m/s D) 600 m/s

Q73. Physics Path →

Closing speed for two objects moving **towards each other** is the sum of their speed magnitudes:

$$c = v_1 + v_2$$

Substitute values:

$$c = 20 + 30 = 50 \text{ m/s}$$

Think: When approaching head-on, closing speed is the sum of speeds, not their difference.

Answer: (C) 50 m/s

Q74. Two cyclists are moving in the same direction with constant speeds of 5 m/s and 8 m/s. If the initial separation between them is 30 m (with the slower cyclist ahead), the time taken by the faster cyclist to catch up with the slower cyclist is:

A) 3 s B) 6 s C) 10 s D) 15 s

Q74. Physics Path →

Catch-up time is given by:

$$t = \frac{\text{initial separation}}{\text{closing speed}}$$

Here, separation = 30 m, closing speed = $8 - 5 = 3$ m/s.

$$t = \frac{30}{3} = 10 \text{ s}$$

Think: When moving in the same direction, closing speed is the difference of speeds.

Answer: (C) 10 s

Q75. Two separate cases have constant positive closing speeds c_1 and c_2 with initial separations d_1 and d_2 respectively. If $d_1 = 2d_2$ and $c_1 = c_2$, the ratio of their meeting times t_1/t_2 is:

A) $1:2$ B) $2:1$ C) $1:4$ D) $4:1$

Q75. Physics Path →

Meeting time is given by:

$$t = \frac{d}{c}$$

For case 1: $t_1 = \frac{d_1}{c_1}$, and for case 2: $t_2 = \frac{d_2}{c_2}$. Given $d_1 = 2d_2$ and $c_1 = c_2$:

$$\frac{t_1}{t_2} = \frac{d_1/c_1}{d_2/c_2} = \frac{2d_2/c}{d_2/c} = 2:1$$

Think: Meeting time is directly proportional to initial separation when closing speed is the same.

Answer: (B) 2:1

Q76. Two cars travel along the same straight axis. When moving in opposite directions, their closing speed is 70 m/s. When moving in the same direction, their closing speed is 10 m/s (with the faster car chasing). What are the individual speeds of the two cars?

A) 40 m/s and 30 m/s B) 50 m/s and 20 m/s

C) 60 m/s and 10 m/s D) 35 m/s and 35 m/s

Q76. Physics Path →

Closing speed in opposite directions:

$$v_1 + v_2 = 70$$

Closing speed in same direction (faster chasing slower):

$$| v_1 - v_2 | = 10$$

Solving simultaneously:

$$v_1 = 40 \text{ m/s},\ v_2 = 30 \text{ m/s}$$

Think: Opposite → sum of speeds; same direction → difference of speeds.

Answer: (A) 40 m/s and 30 m/s

Q77. If the initial separation between two objects moving towards each other with a constant closing speed is doubled while their closing speed is halved, by what factor does the catch-up (meeting) time change?

A) Halved B) Unchanged C) Doubled D) Quadrupled

Q77. Physics Path →

Meeting time is given by:

$$t = \frac{d}{c}$$

If separation doubles ($d_2 = 2d_1$) and closing speed halves ($c_2 = \frac{1}{2}c_1$):

$$t_2 = \frac{2d_1}{\frac{1}{2}c_1} = \frac{4d_1}{c_1} = 4t_1$$

So the catch-up time becomes **four times longer**.

Think: Time ∝ separation ÷ closing speed.

Answer: (D) Quadrupled

Q78. Case 1 has an initial separation d and closing speed c, resulting in meeting time t_1. Case 2 has initial separation $2d$ and closing speed $2c$. What is the ratio of their meeting times t_1/t_2?

A) $1:2$ B) $2:1$ C) $1:1$ D) $4:1$

Q78. Physics Path →

Meeting time is $t = \frac{d}{c}$.

- Case 1: $t_1 = \frac{d}{c}$
- Case 2: $t_2 = \frac{2d}{2c} = \frac{d}{c}$

So,

$$t_1 : t_2 = 1:1$$

Think: Doubling both separation and closing speed cancels out → same meeting time.

Answer: (C) 1:1

Q79. Which of the following statements correctly describes the relationship between the relative velocity of object A with respect to B ($v_{A/B}$) and that of B with respect to A ($v_{B/A}$) in one-dimensional motion?

A) $v_{A/B} = v_{B/A}$

B) $v_{A/B} = -v_{B/A}$

C) $v_{A/B} + v_{B/A} = v_A + v_B$

D) Relative velocity is independent of the reference frame orientation

Q79. Physics Path →

Relative velocity in one-dimensional motion reverses sign when you swap the reference frame.

$$v_{A/B} = -v_{B/A}$$

Think: Same magnitude, opposite direction → symmetry of reference frames.

Answer: (B) $v_{A/B} = -v_{B/A}$

Q80. When calculating the closing speed between two moving objects, under which condition do you add their individual speed magnitudes rather than subtracting them?

A) When both objects move in the exact same direction along the axis

B) When one object is stationary and the other is moving

C) When both objects move in opposite directions along the same axis

D) When both objects have equal velocities

Q80. Physics Path →

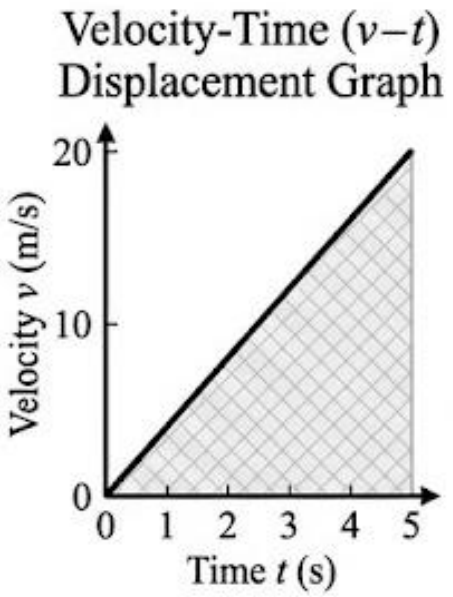
Closing speed is the rate at which two objects approach each other. You **add their speed magnitudes** when they move in **opposite directions along the same axis**, because both velocities contribute to reducing the separation.

Think: Same direction → difference; opposite direction → sum.

Answer: (C) When both objects move in opposite directions along the same axis

H. Graph Intelligence

Q81. Refer to a standard v--t graph where velocity increases linearly from 0 m/s at $t = 0$ s to 20 m/s at $t = 5$ s. What is the total displacement of the particle during this 5 s interval, obtained from the signed area under the graph?



A) 25 m B) 50 m C) 100 m D) 200 m

Q81. Physics Path →

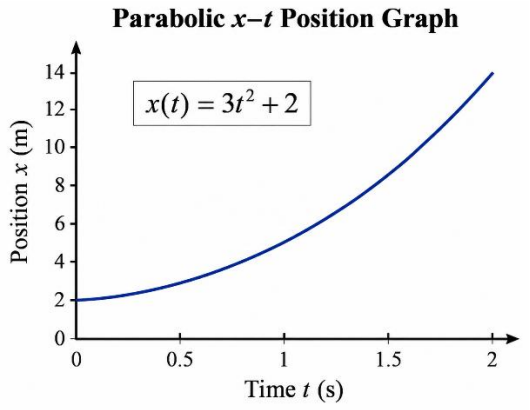
Displacement is the **signed area under the v–t graph**. Here the graph is a triangle with base $t = 5$ sand height $v = 20$ m/s.

$$\text{Displacement} = \frac{1}{2} \times \text{base} \times \text{height} = \frac{1}{2} \times 5 \times 20 = 50\ \text{m}$$

Think: On a velocity–time graph, displacement = area under the curve.

Answer: (B) 50 m

Q82 Consider an x--t graph of a particle where position is given by $x(t) = 3t^2 + 2$. What is the instantaneous velocity of the particle at time $t = 2$ s, determined from the tangent slope of the x--t curve?



A) 6 m/s B) 10 m/s C) 12 m/s D) 14 m/s

Q82. Physics Path →

Instantaneous velocity is the slope of the $x-t$ curve, i.e. the derivative of position:

$$v(t) = \frac{dx}{dt} = \frac{d}{dt}(3t^2 + 2) = 6t$$

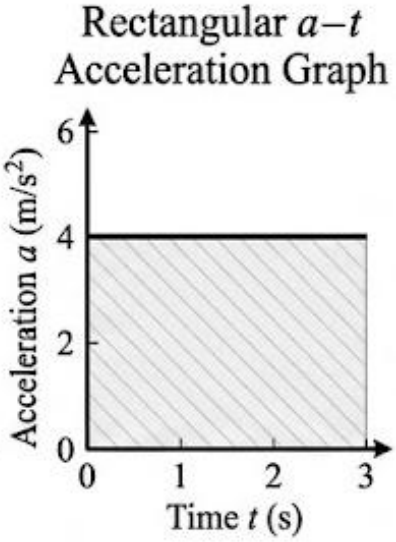
At $t = 2$ s:

$$v(2) = 6 \times 2 = 12 \text{ m/s}$$

Think: On an $x-t$ graph, velocity = slope of tangent.

Answer: (C) 12 m/s

Q83. An a--t graph shows a constant acceleration $a = 4$ m/s^2 acting from $t = 0$ to $t = 3$ s. If the particle starts with an initial velocity of $u = 2$ m/s at $t = 0$, what is its final velocity at $t = 3$ s?



A) 10 m/s B) 12 m/s C) 14 m/s D) 16 m/s

Q83. Physics Path →

Final velocity under constant acceleration is given by:

$$v = u + at$$

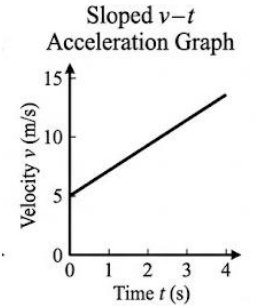
Here, $u = 2$ m/s, $a = 4$ m/s^2, $t = 3$ s.

$$v = 2 + (4)(3) = 2 + 12 = 14 \text{ m/s}$$

Think: On an a–t graph, velocity change = area under the curve.

Answer: (C) 14 m/s

Q84. On a given v--t graph, a straight-line segment connects $(\text{t} = 0, \text{v} = 5 \text{ m/s})$ to $(\text{t} = 4 \text{ s}, \text{v} = 13 \text{ m/s})$. What is the instantaneous acceleration represented by the slope of this line segment?



A) 2 m/s^2 B) 3 m/s^2 C) 4 m/s^2 D) 8 m/s^2

Q84. Physics Path →

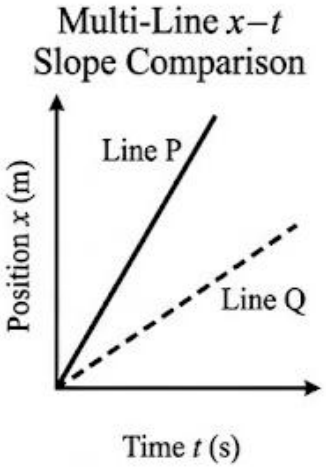
Instantaneous acceleration is the slope of the straight line on the v–t graph:

$$a = \frac{\Delta v}{\Delta t} = \frac{13 - 5}{4 - 0} = \frac{8}{4} = 2 \text{ m/s}^2$$

Think: On a velocity–time graph, slope = acceleration.

Answer: (A) $2\ \text{m/s}^2$

Q85 Two different particles, P and Q, have linear x--t graphs passing through the origin. Particle P has a steeper slope than Particle Q ($\theta_P > \theta_Q$). What is the ratio of their instantaneous velocities ($v_P : v_Q$)?



A) Equal to $1:1$

B) Greater than $1:1$ ($v_P > v_Q$)

C) Less than $1:1$ ($v_P < v_Q$)

D) Dependent on the initial position coordinates

Q85. Physics Path →

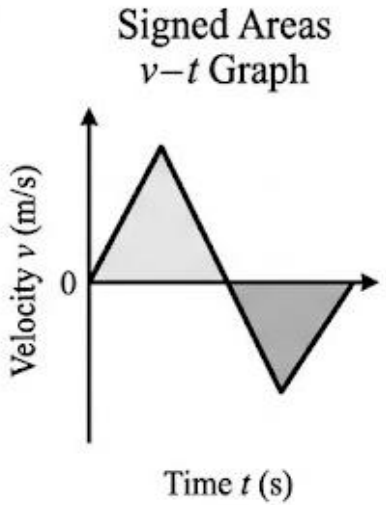
On an $x-t$ graph, the slope of the line gives velocity. A steeper slope means a larger velocity. Since $\theta_P > \theta_Q$, particle P has greater velocity than particle Q.

$$v_P : v_Q > 1:1$$

Think: Steeper slope → higher velocity.

Answer: (B) Greater than 1:1 ($v_P > v_Q$)

Q86 A v--t graph contains two triangular displacement regions: Region 1 above the time axis with area $+16$ m, and Region 2 below the time axis with area -6 m. What is the ratio of the net displacement to the total distance travelled over this interval?



A) $5:11$ B) $16:6$ C) $11:22$ D) $1:1$

Q86. Physics Path →

Net displacement = sum of signed areas:

$$+16 + (-6) = +10\ \text{m}$$

Total distance = sum of magnitudes:

$$16 + 6 = 22\ \text{m}$$

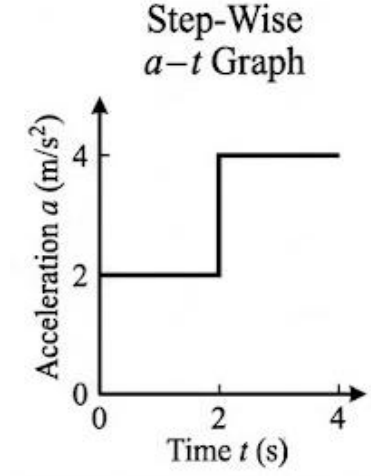
Ratio:

$$\frac{\text{Net displacement}}{\text{Total distance}} = \frac{10}{22} = \frac{5}{11}$$

Think: Displacement uses **signed areas**, distance uses **absolute areas.**

Answer: (A) 5:11

Q87 On an a--t graph, the area under the acceleration-time curve between $t = 0$ and t_1 is A_1, and between t_1 and $2t_1$ is A_2 (where $A_2 = 2A_1$). If the particle starts from rest, what is the ratio of the velocity change in the first interval (Δv_1) to the velocity change in the second interval (Δv_2)?



A) 1: 2 B) 2: 1 C) 1: 4 D) 4: 1

Q87. Physics Path →

Velocity change equals the **area under the acceleration–time graph.**

- First interval: $\Delta v_1 = A_1$

- Second interval: $\Delta v_2 = A_2 = 2A_1$

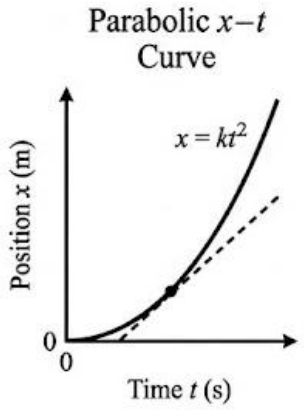
So,

$$\Delta v_1 : \Delta v_2 = A_1 : 2A_1 = 1 : 2$$

Think: On an $a-t$ graph, area = velocity change.

Answer: (A) 1:2

Q88 Consider a parabolic x--t graph described by $x = kt^2$, where k is a positive constant. If the time interval is doubled ($t_2 = 2t_1$), by what factor does the slope of the tangent (instantaneous velocity) increase at the end of the interval?



A) 2 times

B) 4 times

C) $\sqrt{2}$ times

D) Unchanged

Q88. Physics Path →

Instantaneous velocity is the slope of the $x-t$ curve:

$$x = kt^2 \Rightarrow v(t) = \frac{dx}{dt} = 2kt$$

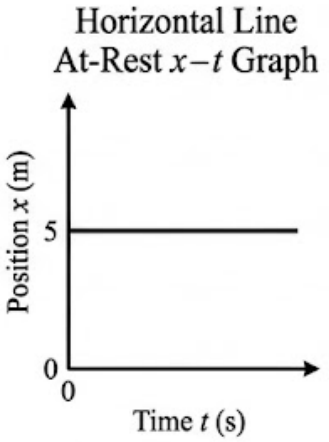
At t_1: $v_1 = 2kt_1$ At $t_2 = 2t_1$: $v_2 = 2k(2t_1) = 4kt_1 = 2v_1$

So the slope (velocity) doubles when time is doubled.

Think: For $x \propto t^2$, velocity $\propto t$.

Answer: (A) 2 times

Q89 A student analyzes an x--t graph where the curve is a horizontal straight line parallel to the time axis. What physical conclusion can be correctly drawn from this graph feature?



A) The particle is moving with constant acceleration

B) The particle is at rest ($v = 0$)

C) The particle has uniform non-zero velocity

D) The particle is undergoing a directional reversal

Q89. Physics Path →

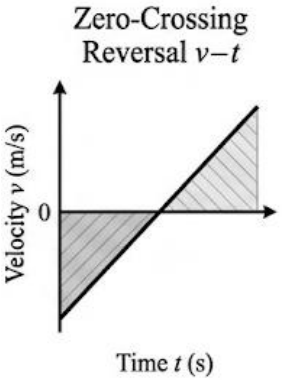
On an $x-t$ graph, a **horizontal line** means the position does not change with time. If position is constant, velocity is zero.

So the particle is **at rest**.

Think: Flat line on position–time graph → no motion.

Answer: (B) The particle is at rest ($v = 0$)

Q90. When calculating total distance travelled from a given v--t graph that dips below the time axis, why must you integrate $\int |v|\, dt$ instead of the standard signed integral $\int v\ dt$?



A) Because areas below the axis represent negative time intervals

B) Because distance is a cumulative scalar path length that never decreases, whereas signed area accounts for backward displacement cancellation

C) Because acceleration becomes negative below the axis

D) Because velocity cannot be negative in physical motion

Q90. Physics Path →

On a $v-t$ graph, the **signed integral** $\int v\ dt$gives displacement, because negative velocity cancels positive motion. But **distance** is the total path length, which must always increase. Therefore, we integrate the **magnitude** of velocity:

$$\text{Distance} = \int |v| \, dt$$

Think: Signed area → displacement; absolute area → distance.

Answer: (B) Because distance is a cumulative scalar path length that never decreases, whereas signed area accounts for backward displacement cancellation