

Describing Motion Around Us - Question Bank

Class 9 Science (Exploration Edition) | Physics Chapter 4

Line Spacing: 1.15

Segment 1: Easy Level Alpha Level

1. Multiple Choice Questions (20 Questions)

1. Which of the following is a scalar quantity?
A) Velocity
B) Displacement
C) Distance
D) Acceleration
2. The SI unit of acceleration is:
A) m/s
B) m·s
C) m/s²
D) cm/s²
3. When an object is at rest, its position with respect to a reference point:
A) Changes continuously
B) Decreases
C) Remains unchanged
D) Becomes zero
4. An athlete completes one lap of a circular track of radius R. The displacement is:
A) $2\pi R$
B) πR
C) $2R$
D) Zero
5. A car travels 30 km in the first hour and 30 km in the second hour. Its motion is:
A) Non-uniform
B) Uniform
C) Accelerated
D) Random
6. The odometer of an automobile measures:
A) Speed
C) Instantaneous velocity
C) Distance travelled
D) Time interval
7. Speedometer of a vehicle measures:
A) Average speed
B) Instantaneous speed
C) Total distance
D) Acceleration
8. The shortest distance between the initial and final position of an object is called:
A) Path length

- B) Displacement
 - C) Motion
 - D) Velocity
9. If the displacement of an object is proportional to square of time, then the object moves with:
- A) Uniform velocity
 - B) Uniform acceleration
 - C) Increasing acceleration
 - D) Decreasing acceleration
10. A body moving in a straight line covers equal distances in equal intervals of time. It possesses:
- A) Uniform speed
 - B) Uniform acceleration
 - C) Variable velocity
 - D) Rest
11. Negative acceleration is also known as:
- A) Speed
 - B) Retardation
 - C) Uniform velocity
 - D) Free fall
12. The slope of a position-time graph gives:
- A) Distance
 - B) Displacement
 - C) Velocity
 - D) Acceleration
13. The area under a velocity-time graph represents:
- A) Acceleration
 - B) Distance/Displacement magnitude
 - C) Speed
 - D) Change in acceleration
14. In uniform circular motion, what remains constant?
- A) Velocity
 - B) Speed
 - C) Acceleration
 - D) Direction
15. If a body moves with a constant velocity, its acceleration is:
- A) Positive
 - B) Negative
 - C) Zero
 - D) Infinite
16. A particle is moving in a circular path of radius r . The displacement after half a circle would be:
- A) Zero
 - B) πr
 - C) $2r$
 - D) $2\pi r$
17. A body thrown vertically upwards reaches a maximum height h and returns. Total distance is:
- A) h
 - B) $2h$
 - C) Zero

- D) $h/2$
18. Which of the following is true for displacement?
- It cannot be zero
 - Its magnitude is always greater than distance
 - It has both magnitude and direction
 - It is a scalar quantity
19. A bus reduces its speed from 80 km/h to 60 km/h in 5 seconds. The acceleration is:
- Positive
 - Negative
 - Zero
 - Undefined
20. The numerical ratio of displacement to distance for a moving object is:
- Always less than 1
 - Always equal to 1
 - Always more than 1
 - Equal to or less than 1
- MCQ Answer Key (Easy):** 1-C, 2-C, 3-C, 4-D, 5-B, 6-C, 7-B, 8-B, 9-B, 10-A, 11-B, 12-C, 13-B, 14-B, 15-C, 16-C, 17-B, 18-C, 19-B, 20-D

2. Subjective Questions (20 Questions) Alpha Level

- Define motion relative to a reference point.
- Differentiate between distance and displacement.
- Under what condition is the magnitude of average velocity equal to average speed?
- What does the odometer of an automobile measure?
- An object has moved through a distance. Can it have zero displacement? Explain.
- Define uniform motion and give one example.
- Define non-uniform motion and give one example.
- What is meant by instantaneous speed?
- Distinguish between speed and velocity.
- Define acceleration and state its SI unit.
- When do you say a body has uniform acceleration?
- Give an example of non-uniform acceleration from daily life.
- What can you say about the motion of an object whose distance-time graph is a straight line parallel to the time axis?
- What can you say about the motion of an object if its speed-time graph is a straight line parallel to the time axis?
- Write the three standard equations of motion for a uniformly accelerated body.
- A farmer moves along the boundary of a square field of side 10 m in 40 s. What will be the magnitude of displacement at the end of 2 minutes 20 seconds?
- Why is uniform circular motion called an accelerated motion?
- A stone is thrown vertically upwards with a velocity of 5 m/s. If its acceleration during motion is 10 m/s^2 downwards, what will be the height attained?
- Define retardation. State its unit.
- What is the significance of the slope of a velocity-time graph?

Segment 2: Moderate Level Beta Level

1. Multiple Choice Questions (20 Questions)

1. A car covers the first half of the distance between two places at 40 km/h and the second half at 60 km/h. The average speed is:
A) 50 km/h
B) 48 km/h
C) 52 km/h
D) 45 km/h
2. A body starts from rest and moves with uniform acceleration of 2 m/s^2 for 10 s. The distance covered is:
A) 100 m
B) 200 m
C) 50 m
D) 20 m
3. An object drops from a cliff. The ratio of the distances travelled in 1s, 2s, and 3s is:
A) 1:2:3
B) 1:3:5
C) 1:4:9
D) 9:4:1
4. The velocity-time graph of an object moving with a non-uniform acceleration is a:
A) Straight line parallel to time axis
B) Straight line inclined to time axis
C) Curved line
D) Zig-zag line only
5. A particle moves along a circle of radius R. It completes half a revolution in time T. The average velocity is:
A) $2R/T$
B) $\pi R/T$
C) Zero
D) R/T
6. Four cars A, B, C, and D are moving on a leveled road. Their distance-time graphs are inclined at 30° , 45° , 60° , and 15° with the time axis respectively. Which car is the fastest?
A) A
B) B
C) C
D) D
7. A body falls freely from a height 'h'. After falling $h/2$, it will possess:
A) Only potential energy
B) Only kinetic energy
C) Less potential energy and more kinetic energy
D) Equal potential and kinetic energy
8. A signal from a spaceship reaches the ground station in five minutes. The speed of the signal is $3 \times 10^8 \text{ m/s}$. The distance of the spaceship is:
A) $9 \times 10^{10} \text{ m}$
B) $9 \times 10^8 \text{ m}$
C) $9 \times 10^9 \text{ m}$
D) $3 \times 10^{10} \text{ m}$
9. A train accelerating uniformly from 36 km/h to 72 km/h covers a distance s. The acceleration is 1 m/s^2 . The value of s is:
A) 150 m
B) 300 m

- C) 200 m
D) 100 m
10. A body at rest is dropped from the top of a tower. It takes 4 s to reach the ground. The height of the tower is ($g = 10 \text{ m/s}^2$):
A) 40 m
B) 80 m
C) 160 m
D) 20 m
11. If the velocity of a body changes from u to v in time t , the average acceleration is given by:
A) $(v+u)/t$
B) $(v-u)/t$
C) $(u-v)/t$
D) $v \cdot u/t$
12. A vehicle travels 4 km at speed 30 km/h and next 4 km at speed 50 km/h. Its average speed is:
A) 40 km/h
B) 37.5 km/h
C) 35 km/h
D) 42.5 km/h
13. An object travels 16 m in 4 s and then another 16 m in 2 s. What is the average speed of the object?
A) 6 m/s
B) 5.33 m/s
C) 8 m/s
D) 4 m/s
14. A sprint runner reaches a maximum speed of 12 m/s in 3 seconds from a stationary start. Find the acceleration.
A) 4 m/s^2
B) 36 m/s^2
C) 2 m/s^2
D) 6 m/s^2
15. A racing car has a uniform acceleration of 4 m/s^2 . What distance will it cover in 10 s after start?
A) 200 m
B) 400 m
C) 100 m
D) 300 m
16. The position-time graph of two objects A and B are straight lines making angles of 30° and 60° with the time axis. The ratio of their velocities $v_A:v_B$ is:
A) 1:3
B) 3:1
C) $1:\sqrt{3}$
D) $\sqrt{3}:1$
17. An object moves up a ramp with a deceleration of 2 m/s^2 . If its initial speed was 6 m/s, how long does it take to stop?
A) 12 s
B) 3 s
C) 4 s
D) 6 s
18. A ball thrown vertically up returns to the thrower after 6 s. The velocity with which it was

thrown up is ($g = 10 \text{ m/s}^2$):

- A) 30 m/s
 - B) 60 m/s
 - C) 15 m/s
 - D) 10 m/s
19. A bullet fired into a wooden target loses half of its velocity after penetrating 3 cm. How much further will it penetrate before coming to rest?
- A) 1 cm
 - B) 2 cm
 - C) 3 cm
 - D) 1.5 cm
20. A motorboat starting from rest on a lake accelerates in a straight line at a constant rate of 3.0 m/s^2 for 8.0 s. How far does the boat travel during this time?
- A) 96 m
 - B) 48 m
 - C) 24 m
 - D) 192 m

MCQ Answer Key (Moderate): 1-B, 2-A, 3-C, 4-C, 5-A, 6-C, 7-D, 8-A, 9-A, 10-B, 11-B, 12-B, 13-B, 14-A, 15-A, 16-A, 17-B, 18-A, 19-A, 20-A

2. Subjective Questions (20 Questions) Beta Level

1. Derive the equation $v = u + at$ graphically.
2. A car moving on a straight highway with a velocity of 54 km/h accelerates to 72 km/h in 5 seconds. Calculate the acceleration and distance traveled.
3. An artificial satellite is moving in a circular orbit of radius 42250 km. Calculate its speed if it takes 24 hours to revolve around the earth.
4. A ball is gently dropped from a height of 20 m. If its velocity increases uniformly at the rate of 10 m/s^2 , with what velocity will it strike the ground? After what time will it strike?
5. A stone thrown vertically upwards takes 4 seconds to reach its maximum height. Calculate the initial velocity and maximum height reached ($g = 10 \text{ m/s}^2$).
6. Differentiate between uniform linear motion and uniform circular motion.
7. Interpret a velocity-time graph showing a straight line slanting downwards to the time axis. What does its intercept on the time axis mean?
8. A body covers 10 m in the 2nd second and 15 m in the 3rd second of its uniform acceleration. Find its initial velocity and acceleration.
9. Explain the term "Reaction Time" with a real-life scenario, such as a driver applying brakes suddenly to avoid a hazard.
10. Show that the area under a velocity-time graph of a uniformly accelerated object gives the displacement using a geometric method.
11. A bus travels a certain distance with a speed of 40 km/h and returns with a speed of 80 km/h. Calculate the average speed for the entire journey.
12. A particle moves 3 m east, then 4 m north. Calculate its distance and displacement.
13. Can a body have a constant speed but a varying velocity? Explain with an example.
14. Can a body have zero velocity but still be accelerating? Explain with an example.
15. Plot a position-time graph for a body moving with increasing non-uniform velocity.
16. A train 100 m long crosses a bridge of length 400 m at a speed of 72 km/h. How long does it take to cross the bridge?
17. Explain how the choice of a reference point affects the description of motion of an object inside a moving train from the perspective of an observer outside.

18. An object starts from rest and accelerates at 4 m/s^2 for 5 seconds, then travels at a constant velocity for 10 seconds, and finally stops in 2 seconds. Draw its qualitative velocity-time graph.
19. A boy runs along a circular track of radius 7 m. He completes one revolution in 44 seconds. Find his speed and average velocity at 22 seconds.
20. A car travels at 30 km/h for 20 minutes and then at 60 km/h for the next 30 minutes. Calculate the total distance covered and the average speed.

Segment 3: Difficult Level Delta Level

1. Multiple Choice Questions (20 Questions)

1. A body covers the first one-third of a distance with velocity v_1 , the second one-third with v_2 , and the last one-third with v_3 . The average velocity is:
 - A) $(v_1+v_2+v_3)/3$
 - B) $3v_1v_2v_3 / (v_1v_2 + v_2v_3 + v_3v_1)$
 - C) $(v_1v_2v_3)/3$
 - D) $3 / (v_1+v_2+v_3)$
2. A particle starting from rest accelerates uniformly to acquire a velocity v in time T . The distance covered by it in the last two seconds of its motion is:
 - A) $2v(T-1)/T$
 - B) $v(T-1)/T$
 - C) $2v(T+1)/T$
 - D) $v(T-2)/T$
3. A body drops from a height H . Total time taken to reach the ground is T . Where is the body at time $T/2$?
 - A) $H/2$ from the ground
 - B) $H/4$ from the top
 - C) $3H/4$ from the ground
 - D) Both B and C
4. An object moves along a straight line with a constant acceleration. If the velocity at a point A is 10 m/s and at point B is 20 m/s, the velocity at the midpoint of AB is:
 - A) 15 m/s
 - B) 15.8 m/s
 - C) 16.2 m/s
 - D) 14.1 m/s
5. A stone is dropped from a rising balloon which is at a height of 80 m and ascending with a velocity of 10 m/s. The time taken by the stone to reach the ground is ($g = 10 \text{ m/s}^2$):
 - A) 4 s
 - B) 5 s
 - C) 4.5 s
 - D) 6 s
6. The displacement of a particle moving in a straight line is given by $x = 2t + 3t^2$. The acceleration at $t = 2\text{s}$ is:
 - A) 3 m/s^2
 - B) 6 m/s^2
 - C) 8 m/s^2
 - D) 12 m/s^2
7. A ball is thrown vertically upward with speed u . At the same time, another ball is dropped

from a height H . They meet at a height $H/2$. The value of u is:

- A) $\sqrt{gH}$
 - B) $\sqrt{2gH}$
 - C) $\sqrt{gH/2}$
 - D) $2\sqrt{gH}$
8. A body moving with uniform acceleration covers 24 m in the 3rd second and 36 m in the 5th second. Its initial velocity was:
- A) 6 m/s
 - B) 9 m/s
 - C) 12 m/s
 - D) 3 m/s
9. A tap drips at a constant rate of 1 drop per second. The distance between the 1st and 3rd drop when the 3rd drop is just leaving the tap is ($g = 10 \text{ m/s}^2$):
- A) 5 m
 - B) 15 m
 - C) 20 m
 - D) 10 m
10. Two trains A and B of length 100 m and 200 m respectively are moving on parallel tracks at 54 km/h and 72 km/h in opposite directions. The time taken to cross each other is:
- A) 8.5 s
 - B) 10 s
 - C) 12 s
 - D) 6 s
11. A rocket is fired vertically upwards such that its engine provides a constant acceleration of 5 m/s^2 for 10 s, after which the fuel is exhausted. The maximum height reached is ($g = 10 \text{ m/s}^2$):
- A) 250 m
 - B) 375 m
 - C) 500 m
 - D) 750 m
12. A car accelerates from rest at a constant rate α for some time, after which it decelerates at a constant rate β to come to rest. If the total time elapsed is t , the maximum velocity attained is:
- A) $(\alpha + \beta)t / (\alpha\beta)$
 - B) $\alpha\beta t / (\alpha + \beta)$
 - C) $\sqrt{(\alpha\beta)t}$
 - D) $(\alpha^2 + \beta^2)t / (\alpha\beta)$
13. For the car in the previous question, the total distance traveled is:
- A) $\alpha\beta t^2 / [2(\alpha + \beta)]$
 - B) $\alpha\beta t^2 / (\alpha + \beta)$
 - C) $(\alpha + \beta)t^2 / (2\alpha\beta)$
 - D) $\alpha\beta t / [2(\alpha + \beta)]$
14. A particle covers half of its total distance with speed v_1 . The rest of the distance is covered in two equal time intervals with speeds v_2 and v_3 . The average speed is:
- A) $2v_1(v_2 + v_3) / (2v_1 + v_2 + v_3)$
 - B) $2v_1(v_2 + v_3) / (v_1 + v_2 + v_3)$
 - C) $v_1(v_2 + v_3) / (2v_1 + v_2 + v_3)$
 - D) $2v_1(v_2 + v_3) / (2v_1 + 2v_2 + v_3)$
15. A body is thrown vertically upwards. If air resistance is taken into account and it is constant, the time of ascent t_1 and time of descent t_2 are related as:
- A) $t_1 = t_2$

- B) $t_1 > t_2$
 C) $t_1 < t_2$
 D) Dependent on the mass
16. A point moves rectilinearly with deceleration whose magnitude depends on velocity v as $a = k \cdot v$, where k is a positive constant. If at $t=0$, velocity is v_0 , the distance covered before it stops is:
 A) v_0/k
 B) $v_0^2/(2k)$
 C) $k \cdot v_0$
 D) Infinite
17. A ball is dropped from a height h on a floor. If the coefficient of restitution is e , the total distance covered by the ball before coming to rest after infinite bounces is:
 A) $h(1+e^2) / (1-e^2)$
 B) $h(1-e^2) / (1+e^2)$
 C) $h / (1-e^2)$
 D) $h \cdot e^2 / (1+e^2)$
18. The velocity-time graph of a particle is given by a semicircle of radius $V_{\max}$ over a time interval T . The average velocity is:
 A) $\pi \cdot V_{\max} / 4$
 B) $V_{\max} / 2$
 C) $\pi \cdot V_{\max} / 2$
 D) $2 \cdot V_{\max} / \pi$
19. A passenger train leaves a station with an acceleration of 0.5 m/s^2 . A freight train had left the same station 10 minutes earlier at a constant speed of 36 km/h . How far from the station does the passenger train catch up with the freight train?
 A) 6 km
 B) 8 km
 C) 12 km
 D) 9 km
20. A stone is thrown vertically upward with a speed of 20 m/s from the top of a tower 60 m high. Find the time when it strikes the ground ($g = 10 \text{ m/s}^2$).
 A) 6 s
 B) 4 s
 C) 5 s
 D) 7 s

MCQ Answer Key (Difficult): 1-B, 2-A, 3-D, 4-B, 5-B, 6-B, 7-A, 8-B, 9-C, 10-B, 11-B, 12-B, 13-A, 14-A, 15-C, 16-A, 17-A, 18-A, 19-B, 20-A

2. Subjective Questions (20 Questions) Delta Level

1. A ball is thrown vertically upwards from the top of a tower of height H with a velocity u . It reaches the ground in time t_1 . If it is thrown vertically downwards from the same tower with the same velocity u , it reaches the ground in time t_2 . If it is simply dropped from the tower, it reaches the ground in time t . Show that $t = \sqrt{t_1 \cdot t_2}$.
2. An object moves along a straight line. It starts from rest and accelerates with a_1 for time t_1 , then moves with uniform velocity for time t_2 , and finally decelerates to rest with a_2 in time t_3 . Derive an expression for the total distance in terms of maximum velocity and total time.
3. A police jeep is chasing a thief who is moving in a straight line at a constant speed of 72 km/h . The jeep starts from rest with a uniform acceleration of 2 m/s^2 when the thief is 100

- m ahead. How long will it take for the police to catch the thief?
4. A stone is dropped from the top of a tower 400 m high. At the same time, another stone is projected vertically upwards from the ground with a velocity of 100 m/s. Find when and where the two stones will meet ($g = 10 \text{ m/s}^2$).
 5. An elevator ascends with an upward acceleration of 2 m/s^2 . At the instant its upward speed is 4 m/s, a loose bolt drops from the ceiling of the elevator, which is 3 m above the elevator floor. Calculate the time taken by the bolt to hit the floor ($g = 10 \text{ m/s}^2$).
 6. The speed-time graph of a particle moving along a fixed direction is shown to be a triangle with a base of 10 s and a peak speed of 12 m/s at $t = 5 \text{ s}$. Find the average speed between $t = 2 \text{ s}$ and $t = 6 \text{ s}$.
 7. Derive the third equation of motion $v^2 = u^2 + 2as$ using the calculus method customized conceptually for Class 9 logic (interpreting small intervals as area additions without complex integral symbols).
 8. A car starts from rest and accelerates uniformly at 2 m/s^2 for 10 seconds. It then maintains a constant speed for 20 seconds. The brakes are then applied, creating a uniform deceleration, and the car stops in 5 seconds. Find the total distance by breaking it down segment by segment.
 9. A metro train travels between two stations A and B. It accelerates uniformly at 1 m/s^2 for the first quarter of the distance, moves with a uniform speed for the next half of the distance, and decelerates uniformly at 2 m/s^2 for the remaining quarter of the distance. If the total distance is 4 km, find the total time taken.
 10. A body is dropped from the top of a tower. During the last second of its fall, it covers $16/25$ th of the total height of the tower. Find the total time of fall and the height of the tower ($g = 10 \text{ m/s}^2$).
 11. Explain the difference between instantaneous velocity and average velocity through a graph where a particle reverses its direction of motion.
 12. A particle is moving in a straight line such that its displacement x at time t is related by $t = \sqrt{x} + 3$. Find the velocity of the particle when its acceleration is zero.
 13. An object is moving in a circular track of radius 14 m. It starts from rest and increases its speed at a uniform rate of 1 m/s^2 . Find its total acceleration magnitude at the end of 2 seconds.
 14. A driver traveling at 108 km/h sees a roadblock 60 m away. If the reaction time of the driver is 0.4 seconds and the brakes can provide a deceleration of 8 m/s^2 , determine if the car collides with the roadblock.
 15. Two bodies are thrown vertically upwards with the same initial velocity u but with a time interval of Δt . Prove that they will meet at a time $t = u/g + \Delta t/2$ from the start of the first body.
 16. A point travels half the distance with a velocity v_0 . The remaining part of the distance was covered with velocity v_1 for half the time, and with velocity v_2 for the other half of the time. Find the mean velocity of the point averaged over the whole time.
 17. A parachutist bails out from an aeroplane and drops 50 m without friction. When the parachute opens, it decelerates at 2 m/s^2 . He reaches the ground with a speed of 3 m/s. How long was he in the air? ($g = 10 \text{ m/s}^2$).
 18. A body moving along a straight line with uniform acceleration has velocities u and v at two points A and B respectively. Find the velocity of the body at a point C such that $AC:CB = 1:2$.
 19. A stone is dropped into a well 80 m deep. The sound of the splash is heard 4.25 seconds after the stone is dropped. Calculate the speed of sound in air ($g = 10 \text{ m/s}^2$).
 20. A particle moves along the x -axis such that its position is given by $x = t^3 - 6t^2 + 9t$. Find the time intervals during which the particle is moving backward (towards the origin).

Segment 4: Olympiad Level Quantum Level

1. Multiple Choice Questions (20 Questions)

1. A particle moves in the xy-plane with a constant acceleration 'a' directed along the negative y-axis. The equation of motion is of the form $y = px - qx^2$, where p and q are positive constants. The velocity of the particle at the origin is:
A) $\sqrt{[a(1+p^2) / (2q)]}$
B) $\sqrt{[a / (2q)]}$
C) $\sqrt{[a \cdot p^2 / (2q)]}$
D) $\sqrt{[a(1+p) / q]}$
2. A man is standing on a long trolley moving with a constant velocity v. If the man starts running on the trolley forward with a velocity u relative to the trolley, the net displacement of the man relative to the ground in time t is:
A) $(v+u)t$
B) vt
C) ut
D) $(v-u)t$
3. A shell is fired from a cannon with a velocity v at an angle θ with the horizontal. At the highest point, it explodes into two equal pieces. One piece retraces its path back to the cannon. The speed of the other piece immediately after explosion is:
A) $3v \cos\theta$
B) $2v \cos\theta$
C) $v \cos\theta$
D) $1.5v \cos\theta$
4. The velocity of a particle moving along a straight line depends on its position x as $v = k \cdot \sqrt{x}$, where k is a positive constant. The average velocity of the particle averaged over the time it takes to cover the first s meters is:
A) $k \cdot \sqrt{s} / 2$
B) $k \cdot \sqrt{s} / 3$
C) $2k \cdot \sqrt{s} / 3$
D) $k \cdot \sqrt{s}$
5. A body moves rectilinearly so that its velocity varies with time as $v = v_0(1 - t/T)$ for $0 \leq t \leq T$. The total distance covered by the body until it stops is:
A) $v_0 \cdot T / 2$
B) $v_0 \cdot T$
C) $v_0 \cdot T / 3$
D) $2v_0 \cdot T / 3$
6. An object is thrown vertically upwards from a platform moving downwards with a constant velocity V. The time taken by the object to return to the platform is:
A) $2u/g$
B) $2(u+V)/g$
C) $2(u-V)/g$
D) u/g
7. A ball is projected vertically upwards from the ground. It passes a certain point P at a height h at times t_1 and t_2 from the start. The initial velocity of projection is:
A) $g(t_1+t_2)/2$
B) $g(t_1+t_2)$
C) $\sqrt{g \cdot t_1 \cdot t_2}$
D) $g \cdot t_1 \cdot t_2 / (t_1+t_2)$

8. For the ball in the previous question, the height h of the point P is:
 - A) $g \cdot t_1 \cdot t_2 / 2$
 - B) $g \cdot t_1 \cdot t_2$
 - C) $g(t_1 + t_2)^2 / 8$
 - D) $g(t_2 - t_1)^2 / 2$
9. A train passes an observer standing on a platform. The front engine passes with velocity u and the rear end passes with velocity v . The middle point of the train passes the observer with a velocity of:
 - A) $(u+v)/2$
 - B) $\sqrt{[(u^2+v^2)/2]}$
 - C) $\sqrt{u \cdot v}$
 - D) $(u^2+v^2)/2$
10. A person walks up a stalled escalator in 90 seconds. When standing on the moving escalator, he is carried up in 60 seconds. How much time would it take him to walk up the moving escalator?
 - A) 36 s
 - B) 45 s
 - C) 30 s
 - D) 24 s
11. The acceleration-time graph of a particle starting from rest is a triangle with a peak acceleration a_0 at time $T/2$ and dropping to zero at time T . The maximum velocity acquired is:
 - A) $a_0 \cdot T / 2$
 - B) $a_0 \cdot T / 4$
 - C) $a_0 \cdot T$
 - D) $a_0 \cdot T / 3$
12. A swimmer can swim in still water with speed v . The river flows with speed u ($u < v$). The swimmer wants to cross the river along the shortest possible path. The angle he must make with the upstream direction is:
 - A) $\sin^{-1}(u/v) + 90^\circ$
 - B) $\cos^{-1}(u/v)$
 - C) $\sin^{-1}(u/v)$
 - D) $\cos^{-1}(u/v) + 90^\circ$
13. A particle is dropped from a height H . At the same time, another particle is thrown horizontally from the same height with a velocity v . Which particle hits the ground first?
 - A) The dropped particle
 - B) The horizontally thrown particle
 - C) Both reach simultaneously
 - D) Depends on their respective masses
14. A disc of radius R rolls without slipping on a horizontal surface with a constant velocity v . The acceleration of the topmost point of the disc is:
 - A) v^2/R towards the center
 - B) Zero
 - C) $2v^2/R$ towards the center
 - D) v^2/R horizontally
15. A block is placed on an inclined plane of slope θ . The incline is accelerated horizontally with an acceleration ' a ' so that the block remains stationary relative to the incline. The value of ' a ' is:
 - A) $g \tan \theta$
 - B) $g \cot \theta$
 - C) $g \sin \theta$

- D) $g \cos\theta$
16. A point moves in a circle of radius R so that its tangential acceleration is constant and equal to a_{τ} . If the point starts from rest, the total acceleration at the moment it completes one full revolution is:
- A) $a_{\tau} \sqrt{1 + 4\pi^2}$
 B) $a_{\tau} \sqrt{1 + 16\pi^2}$
 C) $4\pi \cdot a_{\tau}$
 D) a_{τ}
17. A ball is thrown from the top of a tower at an angle above the horizontal. Which of the following quantities remains constant during its flight (neglecting air resistance)?
- A) Vertical component of velocity
 B) Horizontal component of velocity
 C) Speed
 D) Kinetic energy
18. A particle moves along a path such that its position vector is given by $\mathbf{r} = A \cos(\omega t) \mathbf{i} + B \sin(\omega t) \mathbf{j}$. The path of the particle is a/an:
- A) Circle
 B) Ellipse
 C) Straight line
 D) Parabola
19. A car is traveling at a constant speed v around a circular track of radius R . The magnitude of the change in its velocity vector when it turns through an angle of 60° is:
- A) v
 B) $v\sqrt{3}$
 C) $2v$
 D) Zero
20. A particle starts from the origin at $t = 0$ with an initial velocity of $5 \mathbf{i}$ m/s and moves in the xy -plane with a constant acceleration of $(2 \mathbf{i} + 4 \mathbf{j})$ m/s². The y -coordinate of the particle when its x -coordinate is 24 m is:
- A) 24 m
 B) 32 m
 C) 16 m
 D) 48 m

MCQ Answer Key (Olympiad): 1-A, 2-A, 3-A, 4-A, 5-A, 6-B, 7-A, 8-A, 9-B, 10-A, 11-B, 12-A, 13-C, 14-A, 15-A, 16-B, 17-B, 18-B, 19-A, 20-B

2. Subjective Questions (20 Questions) Quantum Level

- A particle moves rectilinearly with an initial velocity v_0 and an acceleration $a = -k \cdot v^2$, where k is a positive constant. Find the velocity of the particle as a function of distance s covered.
- A stone is projected from the ground with a velocity u at an angle θ with the horizontal. Find the average velocity vector of the stone between the instant of projection and the instant it hits the ground.
- A body moves in a straight line such that its velocity is given by $v = \alpha \cdot \sqrt{x}$. Find the acceleration of the body and show that it is constant.
- Two particles A and B are located at a distance L apart. A starts moving with a constant velocity v perpendicular to the line joining them, while B always moves directly towards A with a constant speed u ($u > v$). Find the time when B catches A.
- A regular hexagon of side length ' a ' has six particles at its vertices. Each particle starts

moving with a constant speed ' v ' directed towards the next particle in a cyclic order. How long will it take for the particles to meet at the center?

6. A ship moves due North at a constant speed of 30 km/h, while another ship B moves due East at a constant speed of 40 km/h. At a certain instant, B is 100 km due West of A. Find the minimum distance between the two ships during their subsequent motion.
7. A body is projected vertically upwards with a velocity u in a medium that exerts a drag force proportional to the square of velocity, $F_{\text{drag}} = m \cdot k \cdot v^2$. Find the maximum height attained by the body.
8. An open truck is moving with a constant acceleration of 2 m/s^2 on a straight horizontal road. A boy standing in the truck throws a ball vertically upwards relative to himself with a speed of 10 m/s. Describe the path of the ball as seen by an observer on the ground.
9. A point moves along a circle of radius R with a deceleration that depends on its speed as $a = k \cdot v^2$, where k is a positive constant. If its initial speed is v_0 , find the speed after it completes one full revolution.
10. A balloon starts rising from the ground with an acceleration of 1.25 m/s^2 . After 8 seconds, a stone is released from the balloon. Find the total time taken by the stone to reach the ground from the moment of release ($g = 10 \text{ m/s}^2$).
11. A particle moves along a straight line such that its displacement x varies with time t as $x^2 = at^2 + 2bt + c$, where a , b , and c are constants. Prove that the acceleration of the particle is inversely proportional to x^3 .
12. A river of width d flows with a uniform velocity u . A swimmer can swim with a velocity v relative to water. Prove that the minimum time required to cross the river is d/v , and find the corresponding drift.
13. A heavy particle is projected from the origin with velocity vector $u = u_x i + u_y j$ under gravity. Find the coordinates of the particle at the highest point of its trajectory.
14. A wheel of radius R rolls without slipping on a horizontal floor with an angular velocity ω and angular acceleration α . Find the absolute acceleration vector of the point of contact of the wheel with the ground at that instant.
15. A chain of length L is kept on a smooth horizontal table such that a fraction of its length hangs over the edge. If it slides down under gravity when released from rest, explain conceptually how the acceleration depends on the instantaneous hanging length x .
16. A boy can throw a ball to a maximum horizontal distance of 100 m. How high vertically upwards can he throw the same ball with the same effort?
17. A particle is constrained to move along a circular wire of radius R . The wire is rotating about its vertical diameter with a constant angular velocity ω . Set up the expression for its velocity vector in terms of the angle θ from the lowest point.
18. A fighter jet flies horizontally at a height of 1960 m with a speed of 360 km/h. It releases a bomb to hit a target on the ground. How far ahead of the target should the bomb be released?
19. A projectile is fired up an inclined plane that makes an angle α with the horizontal. The projectile is fired at an angle β with the inclined surface. Derive the condition for maximum range up the incline.
20. A particle moves along a space curve such that its position coordinates are given by $x = a \cos(t)$, $y = a \sin(t)$, and $z = b \cdot t$. Find the magnitude of its velocity and acceleration vectors at any time t .