PHYSICS CLASS XI
CHAPTER – 3 MOTION IN A STRAIGHT LINE

Q.1. Constant acceleration means that x – t graph will have constant slope? Yes/No.

Ans. Acceleration means that velocity is non-uniform. So, x-t graph will be curved.

Q.2. Find the acceleration and velocity of a ball at the instant it reaches its highest point if it was thrown up with velocity v.

Ans. Acceleration is 9.8 m/s^2 (downwards) and velocity is zero at the highest point.

Q.3. Two particles A and B are moving along the same straight line. B is ahead of A. Velocities remaining unchanged, what would be effect on the magnitude of relative velocity if A ahead of B?

Ans. There will be no effect on the magnitude of relative velocity.

Q.4. When a body accelerates by βt, what is the velocity after time t, when it starts from rest?

Ans. Given, acceleration a = βt

it can be written as $\int dv = \int \beta t dt$

On integrating, we get v = $\frac{\beta t^2}{2} + C = \frac{\beta t^2}{2}$ ($\therefore$ C = 0)

Q.5. Can the relative velocity of two bodies be greater than the absolute velocity of either?

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Ans. Yes, when two bodies move in opposite direction then relative velocity of each is greater than the individual velocities.

Q.6. Write an expression for distance covered in nth second for a uniformly accelerated motion.

Ans. If a is the uniform acceleration, then

$$S(nth) = u + \frac{1}{2} a\,(2n - 1)$$

where, s(nth) is the distance covered in nth second, u is the initial velocity.

Q.7. If position of a particle at instant t is given by x = $2t^3$, find the acceleration of the particle.

Ans. Given, $x = 2t^3$, velocity, $v = \frac{dx}{dt} = \frac{d(2t^3)}{dt} = 6t^2$

∴ Acceleration $a = \frac{dv}{dt} = \frac{d(6t^2)}{dt} = 12t$

Q.8. Consider that the acceleration of a moving body varies with time. What does the area under acceleration – time graph for any time interval represent?

Ans. The area under acceleration-time graph for any time interval represents the change of velocity of the body during that time interval.

Q.9. A bus starting from rest moves with a uniform acceleration of 0.1m/s^2 for 2 min.

Find (i) the speed acquired and (ii) the distance travelled.

Ans. u = 0, a = 0.1m/s^2 and t = 2 min 120 s

(i) v = u + at = 0 + 0.1 × 120 = 12m/s

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(ii) $s = ut + \frac{1}{2}at^2 = 0 + \frac{1}{2} \times 0.1 \times (120)^2$

$= \frac{1}{2} \times 0.1 \times 120 \times 120 = 720$ m

Q.10. The displacement of the particle is given by at^2. What is dependency of acceleration on time?

Ans. Let x be the displacement. Then, $x = at^2$

∴ Velocity of the object, $v = \frac{dx}{dt} = 2at$

Acceleration of the object, $a = \frac{dv}{dt} = 2a$

It means that a is constant.

Q.11. State which of the following situations are possible and give an example for each of these?

(i) An object with a constant acceleration but with zero velocity.

(ii) An object moving in a certain direction with acceleration in the perpendicular direction.

Ans. Both the situations are possible

(i) When an object is projected upwards, its velocity at the top - most point is zero even though the acceleration on it 9.8 m/s^2(g).

(ii) When a stone tied to a string is whirled in a circular path, the acceleration acting on it is always at right angles i.e., perpendicular to the direction of motion of stone (we will study about it in motion in a plane).

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Q.12. Which of the following is true for displacement?

(i) It cannot be zero.

(ii) Its magnitude is greater than the distance travelled by the object.

Ans. Both these statements are not true, because

(i) Its magnitude can be zero.

(ii) Its magnitude is either less than or equal to the distance travelled by the object.

Q.13. The velocity of a particle is given by equation

$$V = 4 + 2\,(C_1 + C_2 t)$$

where C_1 and C_2 are constant. Find the initial velocity and acceleration of the particle.

Ans. The given equation is $v = 4 + 2\,(C_1 + C_2 t)$

$\Longrightarrow \quad v = (4 + 2C_1) + 2C_2 t$

Comparing the above equations wih equation of motion

$$v = u + at$$

Initial velocity, $u = 4 + 2C_1$

Acceleration of the particle = $2C_2$

Q.14. A car travelling with a speed of 90 km/h on a straight road is ahead of a scooter travelling with a speed of 60km/h. How would the relative velocity be altered, if scooter is ahead of the car?

Ans. Let v_c and v_s be the velocities of the car and the scooter respectively.

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v_c = 90 km/h and v_1 = 60 km/h

When the car is ahead of the scooter, then the relative velocity is $v_{cs} = v_c - v_s$ = 90 – 60 = 30 km/h

When the scooter is ahead of the car, then the relative velocity is $v_{cs} = v_c - v_s$ = 90 – 60 = 30 km/h (towards the scooter)

Q.15. Points P, Q and R are in a vertical line such that PQ = QR. A ball at P is allowed to fall freely. What is the ratio of the times of descent through PQ and QR?

Ans. Let t_1 and t_2 be the times of descent through PQ and QR respectively.

Let PQ = QR = h

Then, $h = \frac{1}{2} g t_1^2$ and $2h = \frac{1}{2} g (t_1 + t_2)^2$

By dividing, we get

$\frac{1}{2} = \frac{t_1^2}{(t_1+t_2)^2}$ or $\frac{1}{\sqrt{2}} = \frac{t_1}{t_1+t_2}$

Hence, $t_1 : t_2 = 1 : (\sqrt{2} - 1)$

Q.16. What are uses of a velocity time graph?

Ans. From a velocity – time graph, we can find our

(i) The velocity of a body at any instant.

(ii) The acceleration of the body and

(iii) The net displacement of the body in a given time – interval.

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Q.17. Two trains A and B of length 400 m each are moving on two parallel tracks with a uniform speed of 72 km h^{-1} in the same direction with A ahead of B. The driver of B decides to overtake A and accelerates by 1ms^{-2}. If after 50 s, the guard of B just brushes past the driver of A, what was the original distance between them?

Ans. For a train A, u = 72 km/h^{-1}

$$= \frac{72\times1000}{60\times60} = 20\ ms^{-1}$$

t = 50 s, a = 0, x = x_A

As, $x = ut + \frac{1}{2}at^2$

$\therefore x_A = 20 \times 50 + \frac{1}{2} \times 0 \times 50^2 = 1000$ m

For train B, u = 72 km/h = 20 ms^{-1}

a = 1 m/s^2 , t = 50s, x = x_B

As, $x = ut + \frac{1}{2}at^2$

$\therefore x_B = 20 \times 50 + \frac{1}{2} \times 1 \times 50^2 = 2250$ m

Taking the guard of the train B in the last compartment of the train B, it follows that original distance between the two trains = length of train A + length of train B.

$= x_B – x_A$

or original distance between the two trains is given by

= 2250 – 1000 = 1250

or original distance between the two trains

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= 1250 – 800 = 450 m

Q.18. Two towns A and B are connected by a regular bus service with a bus leaving in either direction every t min. A man cycling with a speed of 20 km/h in the direction A to B notices that a bus goes past him every 18 min in the direction of his moon and every 6 min in the opposite direction. What is the period T of the bus service and with what speed (assumed constant) do the buses ply on the road?

Ans. Let v km/h be the constant speed with which the buses plying between the towns A and B. The relative velocity of the bus (for the motion A to B) with respect to the cyclist (i.e., in the direction in which the cyclist is going = (v – 20) kmh^{-1}. The relative velocity of the bus from B to A with respect to the cyclist (v + 20) km/h.

The distance travelled by the bus in time T (minutes) = vT As per question,

$$\frac{vT}{v-20} = 18 \text{ or } vT = 18v - 18 \times 20$$

and $$\frac{vT}{v+20} = 6 \text{ or } vT = 6v + 20 \times 6$$

By Eqs. (i) and (ii), we get

$$18v - 18 \times 20 = 6v + 20 \times 6$$

or $$12v = 20 \times 6 + 18 \times 20 = 480$$

or $$v = 40 \text{ km/h}$$

Putting this value of v in Eq. (i), we get

$$40T = 18 \times 40 - 18 \times 20$$

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= 18 × 20

or T = 18 × 20/40 = 9 min

Q.19. A player throws a ball upwards with an initial speed of 29.4 ms^{-1}.

(i) What is the direction of acceleration during the upward motion of the ball?

(ii) What are the velocity and acceleration of the ball at the highest point of its motion?

(iii) Choose x = 0 and t = 0 be the location and time at its highest point, vertically downward direction to be the positive direction of X – axis and give the signs of position, velocity and acceleration of the ball during its upward and downward motion.

(iv) To what height does the ball rise and after how long does the ball return to the player's hands. (Take g = 9.8 ms^{-2} and neglect air resistance)

Ans. (i) Since, the ball is moving under the effect of gravity, the direction of acceleration due to gravity is always vertically downwards.

(ii) At the highest point, the velocity of the ball becomes zero and acceleration is equal to the acceleration due to gravity = 9.8 ms^{-2} in vertically downward direction.

(iii) When the highest point is chosen as the location for x = 0 and t = 0 and vertically downward direction to be the positive direction of x – axis and upward direction as negative direction of x – axis.

During upward motion, sign of positive is negative, sign of velocity is negative and sign of acceleration is positive.

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(iv) Let t be the time by the ball to reach the highest point where height from ground be s.

Taking vertical upward motion of the ball, we have u = - 29.4 ms^{-1} , a = 9.8 ms^{-2}, v = 0, s = S, t = ?

As, $v^2 - u^2 = 2as$

∴ $0 - (-29.4)^2 = 2 \times 9.8 \times S$

or $S = \frac{(29.4)^2}{2\times 9.8} = -44.1$ m

Here negative sign shows that the distance is covered in upward direction.

As, $v = u + at$

∴ $0 = -29.4 + 9.8 \times t$

Or $t = \frac{29.4}{9.8} = 3s$

It means time of ascent = 3 s

When an object moves under the effect of gravity alone, the time of ascent is always equal to the time of descent.

Therefore, total time after which the ball returns to the player's hand = 3 + 3 = 6 s.

Q.20. Read each statement below carefully and state with reasons and examples if it is true or false.

A particle in 1-D motion

(i) with zero speed at an instant may have non-zero acceleration at that instant.

(ii) with zero speed may have non-zero velocity.

(iii) with constant speed must have zero acceleration.

(iv) with positive value of acceleration must be speeding up.

Ans. (i) True, when a body is thrown vertically upwards in the space, then at the highest point, the body has zero speed but has downward acceleration equal to the acceleration due to gravity.

(ii) False, because velocity is the speed of body in a given direction. When speed is zero, the magnitude of velocity of body, hence velocity is zero.

(iii) True, when a particle is moving along a straight line with a constant speed, its velocity remains constant with time. Therefore, acceleration (i.e., change in velocity/time) is zero.

(iv) False, if the initial velocity of a body is negative, then even in the case of positive acceleration, the body speeds up when the acceleration acts in the direction of motion.

Q.21. A ball is dropped from a height of 90 m on a floor. At each collision with the floor, the ball loses one tenth of its speed. Plot the speed – time graph of its motion between t = 0 to 12 s. (g = 10 ms^{-2})

Ans. Taking vertical downward motion of ball from a height 90 m, we have u = 0, a = 10m/s^2, s = 90m, s = 90 m, t = ? ; u = ?

$t = \sqrt{\frac{2s}{a}} = \sqrt{\frac{2\times90}{10}} = 3\sqrt{2}$ s = 4.24 s

$u = \sqrt{2as} = \sqrt{2 \times 10 \times 90} = 30\sqrt{2}$ m/s

Rebound velocity of ball

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u' = $\frac{9}{10}$ u = $\frac{9}{10}$ × $30\sqrt{2}$ = $27\sqrt{2}$ m/s

Time to reach the highest point is

t' = $\frac{u'}{a}$ = $\frac{27\sqrt{2}}{10}$ = $2.7\sqrt{2}$ = $2.7\sqrt{2}$ = 3.81s

Total time = t + t' = 4.24 + 3.81 = 8.05 s

The ball will further 3.81 s to fall back to floor, where its velocity striking the floor

= $27\sqrt{2}$ m/s

Velocity of ball after striking the floor

= $\frac{9}{10} \times 27\sqrt{2}$

= 243 $\sqrt{2}$ m/s

Total time elapsed before upward motion of bal

= 8.05 + 3.81 = 11.86s

Q.22. A police van moving on a highway with a speed of 30 kmh^{-1} fires a bullet at a theif's car speeding away in the same direction with a speed of 192 kmh^{-1}. If the muzzle speed of the bullet is 150 ms^{-1} with what speed does the bullet hit the theif's car? (Note, obtain that speed which is relevant for damaging the theif's car?).

Ans. Muzzle speed of bullet, v_B = 150 ms^{-1}

= 150 × $\frac{18}{5}$ = 540 kmh^{-1}

Speed of polce van, v_P = 30 km/h

Speed of theif's car, v_T = 192 km/h

Since the bullet is sharing the velocity of the police van, its effective velocity is

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$v_B = v_B + v_p$

$= 540 + 30 = 570$ km/h

The speed of the bullet w.r.t. the thief's car moving in the same direction.

$v_{BT} = v_B – v_T = 570 – 192 = 378$ km/h

$= \frac{378\times1000}{60\times60} = 105ms^{-1}$

Q.23. A car starts from rest and accelerates from 0 to 97.0 km/h (60.3 m/h) in 9.00 s. Compute the car's average acceleration.

Ans. We apply relation between acceleration and velocity taking the x – axis to be the direction of motion.

$$a_x = \frac{\Delta v_x}{\Delta t}$$

$$= \frac{97.0km/h\ -0}{9.00s}$$

$$= 10.8 \text{ km/h-s}$$

We read this answer as 10.8 kilometers per hour per second, which means that, on the average, the car's velocity increased by 10.8 km/h each second. A system of units more often used for acceleration is metre per second or per metre per second squared.

Converting to these units, we find

$$a_x = \left(10.8\frac{km}{h-s}\right)\left(\frac{1000m}{1\ km}\right)\left(\frac{1h}{3600s}\right)$$

$$= 3.00 \text{ m/s}^2$$

The meaning of the numerical value is that, on the average, the car's velocity is increased 3.00 m/s each second, as illustrated in figure.

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Although the figure is based on the assumption of a constant acceleration of 3.00 m/s^2, the car could have had acceleration of 3.00 m/s^2 , the car could have had acceleration that varied and simply averaged 3.00 m/s^2.

Q.24. A jet plane beginning its take off moves down the runway at a constant acceleration of 4.00 m/s^2.

(i) Find the position and velocity of the plane 5.00 s after it begins to move.

(ii) If a speed of 70.0 m/s is required for the plane to leave the ground, how long a runway is required?

Ans. Because the acceleration is constant, we can apply the equations of motion derived above.

(i) We take the origin of the x – axis to be the initial position of the plane, so that $x_0 = 0$.

It is useful to begin by listing all the data given in the problem.

$$a = 4.00\ m/s^2$$

$$v = 0,\ x = 0$$

The problem may be stated in terms of the symbols as follows

Find x and v at t = 5.00 s

When x and u are zero, these two equation reduce to

$$v = at \text{ and } x = \frac{1}{2}at^2$$

At t = 5.00 s

$$v = (4.00 m/s^2)(5.00 s) = 20.0\ m/s$$

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$x = \frac{1}{2}(4.00\ m/s^2)\ (5.00s)^2$

$= 50.0$ m

(ii) The problem here may be stated as

Find x when v = 70.0 m/s

It contains the single unknown x, as well as a and v ,

which are known with u = 0, $v_x^2 = 2a_x x$

Solving for x, we obtain

$$x = \frac{v^2}{2a} = \frac{(70.00\ m/s)^2}{2(4.00\ m/s^2)} = 613\text{ m}$$

Q.25. A car starting from rest, accelerates at the rate f through a distance s, then continues at constant speed for some time t and then decelerates at the rate f/2 to come to rest. If the total distance is 5s, then prove that s = $\frac{1}{2}$ ft^2.

Ans. For accelerated motion,

u = 0, a = f, s = s

As $v^2 - u^2 = 2as$

∴ $v_1^2 - 0^2 = 2\ fs \Longrightarrow v_1 = \sqrt{2fs}$,

Distance travelled $s_2 = v_1 t = \sqrt{2fst}$

For decelerated motion,

$u = \sqrt{2fs}$, a = - f/2, v = 0

As $v^2 - u^2 = 2as$,

∴ $0^2 - (\sqrt{2fs})^2 = 2 \times (-f/2)s_3$

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Distance travelled, $s_3 = 2s$

Given, $s + s_2 + s_3 = 5s$

or $s + \sqrt{2fst} + 2s = 5s \Longrightarrow \sqrt{2fst} = 2s$

or $s = \frac{1}{2} ft^2$

Q.26. A body is projected vertically upwards from A, the top of a tower it reaches the ground in it t_1 second. If it is projected vertically downwards from A with the same velocity it reaches the ground in t_2 second. If it falls freely, from A, prove that it would reach the ground in $\sqrt{t_1 t_2}$ second.

Ans. Using relations

Consider upwards as negative and downward as positive.

$$h = ut_1 + \frac{1}{2} gt_1^2 \quad \text{....... (i)}$$

and $$h = ut_2 + \frac{1}{2} gt_2^2 \quad \text{........ (ii)}$$

Subtracting both Eqs. (i) and (ii), we get

or $0 = u(t_2 + t_1) + \frac{1}{2} gt_2^2 - \frac{1}{2} gt_1^2$

or $u(t_2 + t_1) + \frac{1}{2} g(t_2 + t_2)(t_2 - t_2) = 0$

or $u + \frac{1}{2} g(t_2 + t_1) = 0$ or $u = -\frac{g}{2}(t_2 - t_1)$ ..... (iii)

From Eqs. (i0 and (iii), we get

Now, $h = \frac{gt_1}{2}(t_2 - t_1) + \frac{1}{2} gt_1^2 = \frac{1}{2} gt_1 t_2$ ...... (iv)

Again, when the body falls freely.

$h = \frac{1}{2} gt^2$; $\frac{1}{2} gt_1 t_2 = \frac{1}{2} gt^2$ (from Eq. iv)

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or $t = \sqrt{t_1 t_2}$

Q.27. Sunil went to the bank to deposit some money in his saving account. When he was depositing money in queue suddenly he heard the sound of a bullet. Two masked men came into the bank and held the cashier at gun point. They were asking for whole of the cash. Everyone in the bank became afraid and silent, mask men looted the bank and ran away on their bike. Sunil immediately followed them on his bike but gun men had crossed the turning. But after a long chase, he was able to caught the thieves and handed them over to police at the nearest police station.

(i) What values of Sunil are displayed?

(ii) If the gun men's bike crosses the turning at a speed of 72 km/h and Sunil follows it at a speed 108 km/h crossing the turning 10 s later than first bike. Assuming that they travel at constant speed, how far from the turning will Sunil catch the thieves?

(iii) When is the acceleration of vehicle more, when accelerator is pushed or brake pedal is pushed hard?

Ans. (i) The values displayed by Sunil is the courageous work in catching the thieves.

(ii) Speed of gunmen's bike = 72km/h

$$= 72 \times \frac{5}{18} = 20 \text{ m/s}$$

Speed of Sunil's bike = 108 km/h

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$= 108 \times \frac{5}{18} = 30$ m/s

Let t be the time taken by Sunil to catch the thieves

∴ $30t = 20(t + 10) \Longrightarrow t = 20$ s

Thus, distance travelled by Sunil

$= 30 \times 20 = 600$ m

(iii) Acceleration is more when brake pedal is pushed hard because vehicle suddenly comes to rest i.e., rate of change of velocity is large.

Q.28. Shruti goes to school with his brother Alok in their own car. The school is about 10 km apart from their home. They drive on alternate days. Alok is a very careful driver but Shruti drives rushly. She takes 3 min less than Alok in reaching the school. Alok advices Shruti to drive safely but she hardly listens.

(i) What values are displayed by Alok? Do you agree with him?

(ii) What is the difference between average speeds of Shruti and Alok if later takes 15 min to drive to the school?

Ans. (i) Alok displays safety concern for her sister. Rush driving can lead to any unfortunate incident. We agree with Alok that driving must be careful and safe.

(ii Average speed of Alok

$$v_1 = \frac{Distance}{Time} = \frac{10\ km}{15/60} = 40 km/h$$

Time taken by Shruti to reach the school

$= 15 - 3 = 12$ min

∴ Difference between average speed

$$= v_2 - v_1 = 50 - 40 = 10 \text{ km/h}$$

Q.29. It is a common observation that rain clouds can be at about a kilometer altitude above the ground.

(i) If a rain drop falls from such a height freely under gravity, what will be its speed? Also calculate in km/h ($g = 10m/s^2$).

(ii) A typical rain drop is about 4 mm diameter. Momentum is mass × speed in magnitude. Estimate its momentum when it hits ground.

(iii) Estimate time required to flatten the drop.

(iv) Rate of change of momentum is force. Estimate how much force such a drop would exert on you.

(v) Estimate the order of magnitude force on umbrella. Typical lateral separation between two rain drops is 5 cm.

(Assume that umbrella is circular and has a diameter of 1 m and cloth is not pierced through it.)

Ans. Here, height (h) = 1km = 1000 m, $g = 10m/s^2$

(i) Velocity attained by the rain drop in freely falling through a height h.

$$v = \sqrt{2gh} = \sqrt{2 \times 10 \times 1000}$$

$$= 100\sqrt{2} \text{ m/s}$$

$$= 100\sqrt{2} \times \frac{60\times60}{1000} \text{ km/h}$$

$$= 360\sqrt{2} \text{ km/h} \approx 510 \text{ km/h}$$

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(ii) Diameter of the drop (d) = 2r = 4mm

∴ Radius of the drop (r) = 2mm = 2×10^{-3} m

Mass of a rain drop (m) = V × p

$= \frac{4}{3}\pi r^3$ p = $\frac{4}{3} \times \frac{22}{7} \times (2 \times 10^{-3})^3 \times 10^3$

(∵ Density of water = $10^3\ kg/m^3$)

$\approx 3.4 \times 10^{-5}$ kg

Momentum of the rain drop (p) = mv

$= 3.4 \times 10^{-5} \times 100\sqrt{2}$

$\approx 4.7 \times 10^{-3}$ kg-m/s

(iii) Time required to flattern the drop

= time taken by the drop to travel the distance equal to the diameter of the drop near the ground

$t = \frac{d}{v} = \frac{4\times10^{-3}}{100\sqrt{2}} = 0.028 \times 10^{-3}$ s

$= 2.8 \times 10^{-5}$ s

(iv) Force exerted by a rain drop

$F = \frac{Change\ in\ momentum}{Time}$

$= \frac{p-0}{t} = \frac{4.7\times10^{-3}}{2.8\times10^{-5}} \approx 168N$

(v) Radius of the umbrella (R) = $\frac{1}{2}$ m

∴ Area of the umbrella (A) = πR^2

$= \frac{22}{7} \times \left(\frac{1}{2}\right)^2 = \frac{22}{28}$

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$= \frac{11}{14} \approx 0.8\ m^2$

Number of drops striking the umbrella simultaneously with average separation of 5 cm or

$= 5 \times 10^{-2}$ m

$= \frac{0.8}{(5\times10^{-2})^2} = 320$

∴ Net force exerted on umbrella

= 320 × 168 = 53760 N

Q.30. A motor car moving at a speed of 72 km/h cannot come to a stop is less than 3.0 s while for a truck time interval is 5.0 s. On a highway, the car is behind the truck both moving at 72 km/h. The truck gives a signal that it is going to stop at emergency. At what distance the car should be from the truck so that it does not bumb onto (collide with) the truck. Human response time is 0.5 s.

Ans. Given, speed of the car as well as truck = 72 km/h

$= 72 \times \frac{5}{18}$ m/s = 20 m/s

Retarded motion for truck

$v = u + a_t\, t$

$0 = 20 + a_t \times 5$

or $a_t = -4\ m/s^2$

Retarded motion for the car

$v = u + a_c t$

$0 = 20 + a_c \times 3$

$a_c = -\frac{20}{3}$ m/s^2

Let car be at a distance x from truck, when truck gives the signal and t be the time taken to cover this distance.

As human response time is 0.5 s, therefore time of retarded motion of car is (t – 0.5) s.

Velocity of car after time t,

$v_c = u - at$

$= 20 - \left(\frac{20}{3}\right)(t - 0.5)$

Velocity of truck after time t,

$v_t = 20 - 4t$

To avoid the car bumb onto the truck, $v_c = v_t$

$20 - \frac{20}{3}(t - 0.5) = 20 - 4t$

or $4t = \frac{20}{3}(t - 0.5)$

or $t = \frac{5}{3}(t - 0.5)$

or $3t = 5t - 2.5$

or $t = \frac{2.5}{2} = \frac{5}{4}$ s

Distance travelled by the truck in time t,

$s_t = u_t t + \frac{1}{2} a_t t^2$

$= 20 \times \frac{5}{4} + \frac{1}{2} \times (-4) \times \left(\frac{5}{4}\right)^2$

$= 25 - 3.125 = 21.875$ m

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Distance travelled by the car in time t

= Distance travelled by the car in 0.5 s

(without retardation) + Distance travelled by car in (t – 0.5) s (with retardation)

$s_c = (20 \times 0.5) + 20\left(\frac{5}{4} - 0.5\right) - \frac{1}{2}\left(\frac{20}{3}\right)\left(\frac{5}{4} - 0.5\right)^2$

$= 23.125$ m

$\therefore s_c - s_c = 23.125 - 21.875$

$= 1.250$ m

Therefore, to avoid the bumb onto the truck, the car must maintain a distance from the truck more than 1.250 m.

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