RELATIVE MOTION

Motion is always a relative term. The motion, so far discussed was relative to a stationary origin. If the reference is now changed to a body, which may / may not be moving, then the motion is termed as *Relative motion*.

We can interpret 4 types of equations for relative motion.

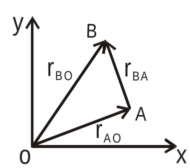
(1) ORIGIN SHIFTING

Until now, the reference point was a stationary point i.e. origin O. So, for any moving body B, motion defining parameters were

$r, v, a \equiv r_B, v_B, a_B \equiv r_{BO}, v_{BO}, a_{BO}$

Now, if we change that stationary reference point O with a body A, which is having it's own position, velocity and acceleration wrt origin O, then the new parameters describing motion of B wrt A will be r_{BA}, v_{BA}, a_{BA}.

In vector form



from triangle law of vector addition

$$\vec{r}_{AO} + \vec{r}_{BA} = \vec{r}_{BO}$$

$\therefore$ $$\vec{r}_{BA} = \vec{r}_{BO} - \vec{r}_{AO} = \vec{r}_B - \vec{r}_A$$

and $$\frac{d}{dt}\vec{r}_{BA} = \frac{d}{dt}(\vec{r}_B) - \frac{d}{dt}(\vec{r}_A) \qquad \therefore \quad \vec{v}_{BA} = \vec{v}_B - \vec{v}_A$$

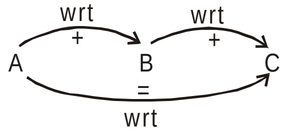
Similarly, $$\vec{a}_{BA} = \vec{a}_B - \vec{a}_A$$

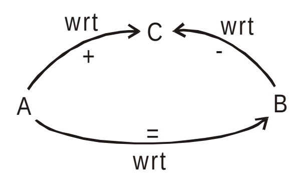
The above treatment can be seen as shifting origin to A and attributing/transferring the velocity and acceleration of A to B in such a manner that A seems to be stationary for B.

(2) RELATION BETWEEN TWO RELATIVE PARAMETERS.

If v_{AB} is relative velocity of A wrt B and v_{BC} is relative velocity of B wrt C, then

$$v_{AB} + v_{BC} = v_{AC}$$





or $$v_{AC} - v_{BC} = v_{AB}$$

where v_{AC} is relative velocity of A wrt C.

EXAMPLE :

A man living in a jungle has to post a letter and come back to initial position as soon as possible. He can go to any of the two post offices named R and L. For Post office R, he has to sail 1 km downstream a flowing river and come back upstream sailing. For post office L, he has to sail his boat 1 km in still lake and come back through still lake only. Which post office should he select ? (Assume speed of river < speed of boat as per man's sailing capacity)

(A) R *(B) L*

(C) either *(D) can't predict until velocity of river is given.*

Sol. (B)

$\vec{V}_{BG} = \vec{V}_{BW} + \vec{V}_{WG}$ (B = Boat, G = ground, W = water)

$V_{net} = V \pm V_o$.

for river case, V_{BG} downstream = $V + V_o$

V_{BG} upstream = $V - V_o$

$$t_R = \frac{x}{V+V_o} + \frac{x}{V-V_o} = \frac{2Vx}{V^2 - V_o^2} = \frac{2x}{V(1-\frac{V_o^2}{V^2})}$$

for lake case, $V_{BG} = V$ (velocity of water = $V_{WG} = V_o = 0$)

$$t_L = \frac{2X}{V} < \frac{2x}{V(1-\frac{V_o^2}{V^2})}$$

(3) NO-NEW FORMULA INTERPRETATION

Equations of motion are equally applicable as

$v_{rel} = u_{rel} + a_{rel}\, t$ or $\vec{v}_{BA} = \vec{u}_{BA} + \vec{a}_{BA} t$

$s_{rel} = u_{rel}\, t + \frac{1}{2} a_{rel}\, t^2$ or $\vec{s}_{BA} = \vec{s}_{oBA} + \vec{u}_{BA} t + \frac{1}{2} \vec{a}_{BA} t^2$

$v^2_{rel} = u^2_{rel} + 2a_{rel}\, s_{rel}$ or $\vec{v}^2_{BA} = u^2_{BA} + 2\vec{a}_{BA}\vec{s}_{BA}$

(4) LAW OF INDEPENDENCE OF DIRECTION (RELATIVE MOTION IN TWO DIMENSIONS)

Here also, we can convert one 2-D motion into two 1-D motions. i.e. first divide the motion in two perpendicular directions and then apply relative equations i.e.

$v_{x\,rel} = u_{x\,rel} + a_{x\,rel}\, t$ Similarly, for y direction $v_{y\,rel} = u_{y\,rel} + a_{y\,rel}\, t$

$s_{x\,rel} = u_{xrel} t + \frac{1}{2} a_{x\,rel}\, t^2$ Similarly, for y direction $s_{y\,rel} = u_{yrel} t + \frac{1}{2} a_{y\,rel}\, t^2$

$(v_{xrel})^2 = (u_{xrel})^2 + 2\, a_{x\,rel}\, s_{x\,rel}$ Similarly, for y direction $(v_{yrel})^2 = (u_{yrel})^2 + 2\, a_{y\,rel}\, s_{y\,rel}$

RELATIVE MOTION IN ONE DIMENSION

<<method of solving problems on relative motion>>

(i) We should adopt a sign convention in the beginning, usually - ⟷ +

(ii) Condition of collision or condition of meeting together

(a) At the time of collision, coordinates of both particles should be same.

i.e. $x_1 = x_2$, and $y_1 = y_2$ (for a 2-D motion)

Similarly, $x_1 = x_2$, $y_1 = y_2$ and $z_1 = z_2$ (for a 3-D motion)

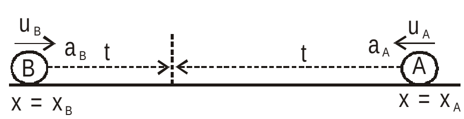
(b) Two particles collide at the same moment. Of course, their time of journeys may be different i.e. they may start at different times (t_1 and t_2 may be different). If they start together, then $t_1 = t_2$.

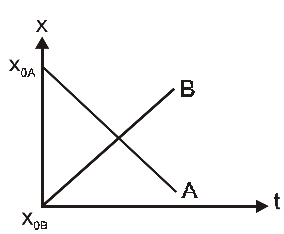
ILLUSTRATIVE CASES OF RELATIVE MOTION IN 1-D

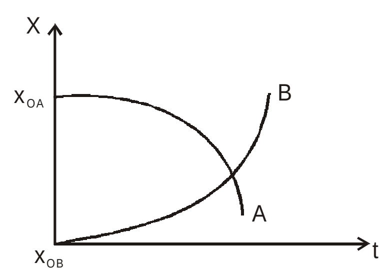
I. WHEN BOTH BODIES ARE MOVING IN OPPOSITE DIRECTION

CASE 1 : TWO BODIES COMING TOWARDS EACH OTHER.

(Direction of velocity and acceleration of both bodies are opposite to each other)







$a_A = a_B = 0$

$\vec{u}_{BA} = \vec{u}_B - \vec{u}_A = u_B - (-u_A) = u_B + u_A$ (sum of individual speeds) (in + x direction)

$\vec{u}_{AB} = \vec{u}_A - \vec{u}_B = -(u_A + u_B)$ (same magnitude but opp. direction) (in - x direction)

Here collision is sure.

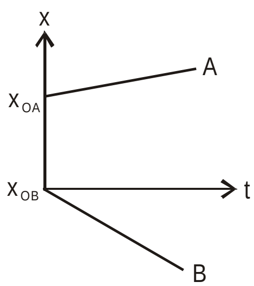
Time of collision can be obtained by solving following equation for t

Position of B at the time of collision = position of A at the time of collision

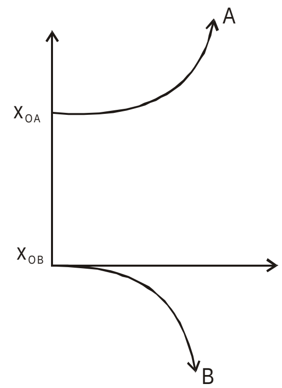
$x_B + u_B t + \frac{1}{2} a_B t^2 = x_A - u_A t - \frac{1}{2} a_A t^2$. (in scalar form)

Q. *Two trains move towards each other, first one with acceleration of 2m/s² & another with acceleration of 3m/s². They collide 50 seconds after starting from rest. Calculate the initial distance between the trains & their final velocities at the time of collision.*

CASE 2 : TWO BODIES MOVING AWAY FROM EACH OTHER.



$(a_A = a_B = 0)$



$\vec{u}_{BA} = \vec{u}_B - \vec{u}_A = -u_B - u_A = -(u_B + u_A)$ [sum of individual speeds, in - x direction]

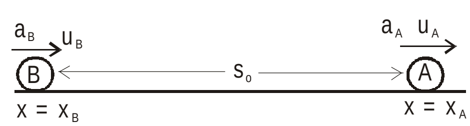
$\vec{u}_{AB} = \vec{u}_A - \vec{u}_B = u_A - (-u_B) = u_A + u_B$ [same magnitude, opp. direction, in + x direction]

collision is not possible.

Summary : When two bodies move in opp. direction to each other then magnitude of relative velocity is the sum of individual speeds.

Q. *Two trains move away from each other with accelerations of 2m/s² & 3m/s² after starting from rest. Calculate the distance between the trains after 50 seconds and their final velocities also.*

II. WHEN BOTH BODIES ARE MOVING IN SAME DIRECTION, BOTH $\vec{v}$ AND $\vec{a}$ ARE IN + X DIRECTION

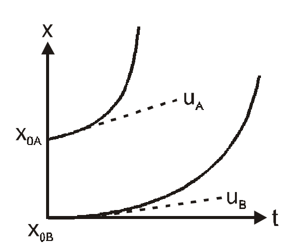


CASE I : $u_A \geq u_B$ AND $a_A > a_B$ THEN B WILL NEVER MEET A

displacement between them goes on increasing.

$$s_{AB} = s_{oAB} + u_{AB}t + \frac{1}{2}a_{AB}t^2 = s_o + (u_A - u_B)\,t + \frac{1}{2}(a_A - a_B)\,t^2$$

surely no collision/meeting possible.



EXAMPLE :

Car A & Car B are moving in the same direction with Car A ahead of Car B. The velocities of Cars A & B are u_A = 7 m/sec & u_B = 5 m/sec respectively. Their accelerations are a_A = 5 m/sec^2 & a_B = 3 m/sec^2 respectively. (a) Will they meet (b) If initial distance between them be 5m then calculate the distance between them after 6 sec. (c) Let distance between A & B at t = 0 be 5m, calculate the time t for which the distance between both cars is 29 m.

Sol. (a) From the equation of linear motion, we have

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

$\therefore$ For a positive value of time t, we can evaluate that A will always cover a larger distance as compared to B

since $u_A > u_B$ & $a_A > a_B$.

Hence, A & B will never meet.

(b) $S_{final} = S_{initial} + (u_A - u_B)\, t + \frac{1}{2} (a_A - a_B)t^2$

$= 5 + (7-5)\, 6 + \frac{1}{2} (5-3)\, (6)^2$

$S_{final} = 5 + 12 + \frac{1}{2} \times 2 \times 36 = 17 + 36 = 53$ m.

(c) S_{final} = 29 m

$S_{initial}$ = 5 m

To find : t

$\therefore\ 29 = 5 + (u_A - u_B)\, t + \frac{1}{2} (a_A - a_B)\, t^2$

or $29 = 5 + (7-5)\, t + \frac{1}{2} (5-3)\, t^2$

or $29 = 5 + 2t + t^2$ or $t^2 + 2t - 24 = 0$

or $(t + 6)(t - 4) = 0$ or t = 4 & - 6 sec.

$\because$ t cannot be negative

$\therefore$ t = 4 sec.

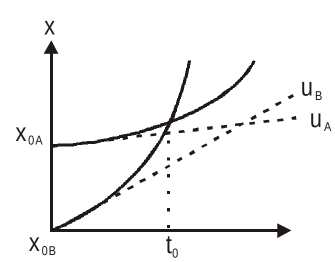
CASE II : $u_A < u_B$ AND $a_A < a_B$ THEN COLLISION IS SURE IF $S_{initial} > O$

collision here means $S_{final,rel} = 0$

(**Note :** If $S_{initial} = 0$ at t = 0, it is the only time when both are together, thereafter B will always be ahead of A.)

Time, at which collision will occur will be obtained by roots of the eqn.

From t, we can calculate v_1 and v_2 at that instant t.



EXAMPLE :

Car A & Car B are moving in the same direction with Car A ahead of car B. Car A has velocity u_A = 5 m/sec, whereas Car B has velocity u_B = 6 m/sec. Both have accelerations given by a_A = 1 m/sec^2 and a_B = 3 m/sec^2. (a) Find the distance between the two after 4 sec, when the initial distance between them is 30 m. (b) After what time t will the distance between the two be zero?

Sol. (a) The final distance between the two cars at t = 4 sec. is

$$S_{final} = S_{initial} + (u_A - u_B)\, t + \frac{1}{2}(a_A - a_B)\, t^2$$

$$= 30 + (5 - 6) \times 4 + \frac{1}{2}(1 - 3)(4)^2$$

$$= 30 - 4 - 16 = 10 \text{ m.}$$

(b) Now, for the distance S_{final} to be zero

$$S_{initial} + (u_A - u_B)\, t_0 + \frac{1}{2}(a_A - a_B)\, t_0^2 = 0$$

or $\quad 30 + (5 - 6)t_0 + \frac{1}{2}(1 - 3)t_0^2 = 0$

or $\quad 30 - t_0 - t_0^2 = 0$

or $\quad t_0^2 + t_0 - 30 = 0$

or $\quad t_0^2 + 6t_0 - 5t_0 - 30 = 0$

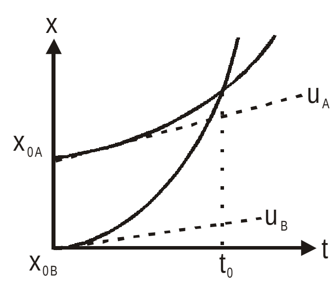
$\therefore \quad (t_0 + 6)(t_0 - 5) = 0$

$\therefore \quad t_0 = -6,\ t_0 = 5$

$\quad t_0 = 5$ sec.

CASE III : $u_A > u_B$, $a_A < a_B$

In this case also, collision is sure because B is gaining velocity.



EXAMPLE :

Two cars A & B with A ahead of B. Velocities of both cars are u_A = 6 m/sec & u_B = 5 m/sec respectively & their accelerations are a_A = 5 m/sec^2 & a_B = 7 m/sec^2.

Let initial distance between them be 6 m.

(a) Find the time when they will meet.

(b) Find velocities of cars A & B when they will meet.

(c) Find distance between the cars at time t = 6 sec. Will Car A be ahead of B or vice versa.

Sol. (a) Now, $S_{final} = 0$, $S_{initial} = 6$ m

Let, t_m be the time of meeting of two cars

$\therefore \quad 0 = 6 + (u_A - u_B)\, t_m + \frac{1}{2}(a_A - a_B)\, t_m^2$

or $\quad 0 = 6 + (6 - 5)\, t_m + \frac{1}{2}(5 - 7)\, t_m^2$ or $0 = 6 + t_m - t_m^2$

or $\quad t_m^2 - t_m - 6 = 0$

$\therefore \quad t_m^2 - 3t_m + 2t_m - 6 = 0$

$(t_m - 3)(t_m + 2) = 0$

$\therefore \quad t_m = 3$ & $t_m = -2$

since t_m cannot be negative

$\therefore \quad t_m = 3$ sec.

(b) Velocity of car A = $v_A = u_A + a_A t_m$

or $\quad v_A$ = (6 + 5x 3) m/sec. = (6 + 15) m/sec. = 21 m/sec.

v_B = (6 + 7 x 3) m/sec = (6 + 21) m/sec. = 27 m/sec.

(c) At t = 0, car A is ahead of B by 6 m

At t = 3 sec, car A meets car B.

Now we have to find the distances travelled by cars A & B from this point.

$\therefore$ After 6 sec. means 3 secs from the point of meeting.

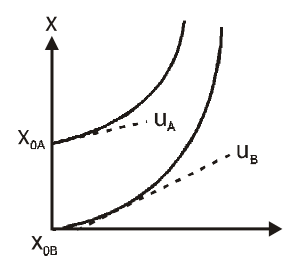
$\therefore \quad S_1 = u_A \times 3 + \frac{1}{2} a_A (3)^2 = 6 \times 3 + \frac{1}{2} \times 5 \times 9 = 18 + 22.5 = 40.5$ m

$S_2 = u_B \times 3 + \frac{1}{2} \times a_B \times 9 = 5 \times 3 + \frac{1}{2} \times 7 \times 9 = 15 + 31.5 = 46.5$ m

$\therefore$ B is ahead of A & Distance between them = 6 m.

CASE IV : $u_A < u_B$, $a_A > a_B$

This is again an indefinite case. Here collision depends on the value of $S_{initial}$ because though the initial velocity of A is less than that of B but A is gaining velocity.



Minimum initial distance d_{min} to avoid collision.

Distance between them initially decreases with time until $v_A < v_B$ but as v_A is increasing at a faster rate, so as soon as v_A becomes greater than v_B then further on distance between them goes on increasing. So, if initially, they are at a separation of d_{min} then at the single instant of meeting together, their speeds will be same & thereafter distance between then will go on increasing.

EXAMPLE :

Two cars A & B with u_A = 5 m/sec and u_B = 7 m/sec with car A ahead of car B. Accelerations of A & B are a_A = 7 m/s² & a_B = 5 m/s².

(a) Let initial distance between them = 1 m.
Calculate the time when they meet.

(b) Let initial distance be 5 m. Calculate the time of meeting.

(c) Calculate their velocities when they meet with initial distance being 1 m.

(d) Calculate velocities of both at t = 2 sec.

Sol. (a) $S_{final} = 0$ for meeting

Let both the cars meet at time = t_m

$\therefore \quad 0 = S_{initial} + (u_A - u_B)\, t_m + \frac{1}{2}(a_A - a_B)\, t_m^2$ or $\quad 0 = 1 + (-2)t_m + (1)\, t_m^2$

or $\quad t_m^2 - 2t_m + 1 = 0$

or $\quad (t_m - 1)^2 = 0 \qquad$ or $\quad t_m = 1$ sec.

(b) Let both the cars meet after time t_m' in this situation

$$S_{final} = S_{initial} + (u_A - u_B)\, t_m' + \frac{1}{2}(a_A - a_B)\, t_m'^2$$

$$0 = 5 + (-2)t_m' + (1)t_m'^2$$

or $\quad t_m'^2 - 2t_m' + 5 = 0 \qquad$ or $\quad t_m' = \dfrac{2 \pm \sqrt{4-20}}{2}$

or $\quad t_m' = \dfrac{2 \pm \sqrt{-16}}{2}$ means imaginary roots.

Hence, they will never meet in this case.

(c) velocities on meeting $\Rightarrow$ when t_m = 1 sec.

$v_A = u_A + a_A t_m \qquad \Rightarrow v_A = 5 + 7 \times 1 = 12$ m/sec.

$v_B = u_B + a_B t_m \qquad \Rightarrow v_B = 7 + 5 \times 1 = 12$ m/sec.

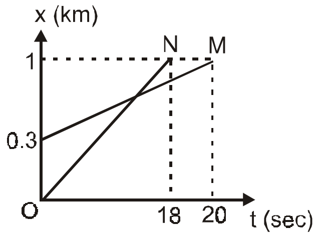
means same velocity.

(d) $v_A' = u_A + a_A \times 2 = \quad 5 + 7 \times 2 = 19$ m/sec.

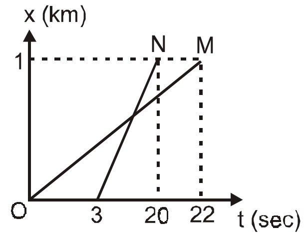
$v_B' = u_B + a_B \times 2 = \quad 7 + 5 \times 2 = 17$ m/sec.

means A is gaining velocity.

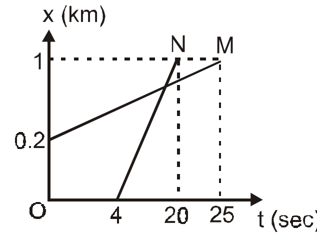
Ex. *Michael Schumacher (M) and Narayan karthikeyan (N) had three races together in the session 2005-06. Their distance time graph for these 1 km straight races are as given below (rules of actual racing neglected/modified). Dot (.) represents starting and ending for each driver. Answer the following questions based on these.*



RACE I



RACE II



RACE III

Q.1 *Who was given initial distance-advantage (kept some meters ahead of the opponent in the beginning of the race) for more no of times:*

(A) M *(B) N* *(C) none* *(D) equal for both.*

Q.2 *Who was more slow on reacting to pistol-fire (a shot from pistol is fired to initiate the race) for more no of times:*

(A) M *(B) N* *(C) none* *(D) equal for both.*

Q.3 *Who won the race for more no of times :*

(A) M *(B) N* *(C) none* *(D) equal for both.*

Q.4 *What is the average speed of michael schumacher in all three cases :*

(A) 0.012 km/s *(B) 0.050 km/s* *(C) 0.0374 km/s* *(D) 0.075 km/s*

Q.5 *What is the average speed of Narayan karthikeyan in all three cases :*

(A) 0.0098 km/s *(B) 0.0235 km/s* *(C) 0.0865 km/s* *(D) 0.05897 km/s*

Q.6 *Whose instantaneous speed is greater than the opponent's one for more no. of times.*

(A) M *(B) N* *(C) none* *(D) equal for both.*

Q.7 *Narayan karthikeyan overtook michael Schumacher during the race for how many times:*

(A) 0 *(B) 1* *(C) 2* *(D) 3*

Q.8 *Michael Schumacher overtook Narayan karthikeyan during the race for how many times:*

(A) 0 *(B) 2* *(C) 3* *(D) 4*

ANS. **1.** (A) **2.** (B) **3.** (B) **4.** (C) **5.** (D) **6.** (B) **7.** (D) **8.** (A)

RELATIVE MOTION

Ex. *Two trains, 75 km apart approach each other on parallel tracks, each moving at 15km/h. A bird flies back and forth between the trains at 20 km/h until the trains pass each other. How far does the bird fly ?*

Sol. PICTURE THE PROBLEM

This problem seems difficult at first, but viewed in the right way, it is actually quite simple. We approach it by first writing an equation for the quantity to be found, the total distance Δs flown by the bird.

1. The total distance equals the average speed times the time.

   Δs = average speed × Δt = (20 km/h) Δt.

2. The time that the bird is in the air is the time taken for the trains to meet. Since they are moving towards each other at 15 km/h, the distance between them decreases at 30 km/h. Use that to calculate how long will it take for the distance between them to go from 75 km to zero.

   $$\Delta t = \frac{75\text{km}}{30\text{km/h}} = 2.5 \text{ h}$$

3. The total distance travelled by the bird is therefore :

   Δs = (20 km/h) (2.5 h) = 50km

REMARK

Some try to solve this problem by finding and summing the distances flown by the bird each time it moves from one train to the other. This makes a relatively easy problem quite difficult. It is important to develop a thoughtful, systematic approach to solving problems. Begin by writing an equation for the unknown quantity in terms of other quantities. Then, process by determining the values for each of the other quantities in the equation.

LEVEL # 1

Q.1 Two trains, each 50m long are travelling in opposite directions with velocity 10 m/s and 15 m/s. The time of crossing is-

(A) 2s (B) 4s (C) $2\sqrt{3}$ s (D) $4\sqrt{3}$ s

Q.2 A 120 m long train is moving in a direction with speed 20 m/s. A train B, moving with 30 m/s in the opposite direction and 130 m long, crosses the first train in a time-

(A) 6s (B) 36s (C) 38s (D) None of these

Q.3 A 210 meter long train is moving due North at a speed of 25 m/s. A small bird is flying due South a little above the train with speed 5m/s. The time taken by the bird to cross the train is-

(A) 6s (B) 7s (C) 9s (D) 10s

Q.4 A police jeep moving with velocity of 45 km/h is chasing a thief in another jeep moving with velocity of 153 km/h. Police fires a bullet with muzzle velocity of 180 m/s. The velocity with which it will strike the car of the thief is-

(A) 150 m/s (B) 27 m/s (C) 450 m/s (D) 250 m/s

Q.5 A boat is sent across a river with a velocity of 8 km/hr. If the resultant velocity of boat is 10 km/hr, then velocity of the river is-

(A) 10 km/hr (B) 8 km/hr (C) 6 km/hr (D) 4 km/hr

Q.6 A train of 150 meter length is going towards north direction at a speed of 10m/sec. A parrot flies at the speed of 5m/sec towards south direction parallel to the railway track. The time taken by the parrot to cross the train is-

(A) 12 sec (B) 8 sec (C) 15 sec (D) 10 sec

LEVEL # 2

MORE THAN ONE CHOICE MAY BE CORRECT :

Q.1 Two cars A and B are initially 40 m apart, A being behind B. The car A is moving with uniform velocity of 10 m/s towards B. The car B starts moving away from A with constant acceleration of 0.2 m/s^2.

The time at which minimum distance between the two occurs is

(A) 20 s (B) 40 s (C) 50 s (D) 60 s

Q.2 In the previous question, the minimum distance between the two is

(A) 650 m (B) 150 m (C) 250 m (D) 300 m

Q.3 Two particles move towards each other with same initial velocity but one moves with constant acceleration and the other moves with the same constant deceleration. Choose the correct statement (s).

(A) The distance between the two particles remains constant

(B) The distance between the two particles decreases at a constant rate

(C) The distance between the two particles decreases with an increasing rate

(D) None of these

Q.4 An observer moves with a constant speed along the line joining two stationary objects. He will observe that the two objects

(A) have the same speed (B) have the same velocity

(C) move in opposite directions (D) move in the same direction

Q.5 A motorist moves at a constant speed of 10 m/s. Two seconds later, another motorist starts in the same direction at a constant acceleration of 2 m/s^2. The second one overtakes the first after travelling approximately-

(A) 12 m (B) 120 m (C) 140 m (D) 1200 m

Q.6 A particle is projected from A vertically upwards with a speed of 50 m/s and another is dropped simultaneously from B which is 200 m vertically above A. They cross each other after-

(A) 4s (B) 5s (C) 6s (D) 8s

Q.7 Two trains take 3s to pass one another, when going in opposite directions, but only 2.5 sec if the speed of one is increased by 50%. The time, one would take to pass the other when going in the same direction at the original speed is-

(A) 10 s (B) 12 s (C) 15 s (D) 18 s

RELATIVE MOTION

Q.8 A train is moving southwards at a speed of 30 ms^{-1}. A monkey is running northwards on the roof of the train with a speed of 5 ms^{-1}. What is the velocity of the monkey as observed by a person standing on the ground?

(A) 35 ms^{-1} in the southward direction
(B) 35 ms^{-1} in the northward direction
(C) 25 ms^{-1} in the southward direction
(D) 25 ms^{-1} in the northward direction

Q.9 A jet airplane travelling from east to west at a speed of 500 km h^{-1} ejects out gases of combustion at a speed of 1500 km h^{-1} with respect to the jet plane. What is the velocity of the gases with respect to an observer on the ground?

(A) 1000 km h^{-1} in the direction west to east
(B) 1000 km h^{-1} in the direction east to west
(C) 2000 km h^{-1} in the direction west to east
(D) 2000 km h^{-1} in the direction east to west

Q.10 A police van moving on a highway with a speed of 36 km h^{-1} fires bullet at a thief's car speeding away in the same direction with a speed of 108 km h^{-1}. If the muzzle speed of the bullet is 140 ms^{-1}, with what speed will the bullet hit the thief's car?

(A) 120 ms^{-1}
(B) 130 ms^{-1}
(C) 140 ms^{-1}
(D) 150 ms^{-1}

Q.11 Two persons P and Q are standing 54 m apart on a long moving belt. Person P rolls a round stone towards person Q with a speed of 9 ms^{-1} with respect to the belt. If the belt is moving with a speed of 4 ms^{-1} in the direction from P to Q, what is the speed of the stone with respect to an observer on a stationary platform?

(A) 4 ms^{-1}
(B) 5 ms^{-1}
(C) 9 ms^{-1}
(D) 13 ms^{-1}

Q.12 In the previous question, what will be the speed of the stone with respect to an observer on a stationary platform if person Q rolls the stone with a speed of 9 ms^{-1} with respect to the belt towards person P.

(A) 13 ms^{-1}
(B) 9 ms^{-1}
(C) 4 ms^{-1}
(D) 5 ms^{-1}

Q.13 A train is moving eastwards with a velocity of 10 m/s. On a parallel track another train passes with a velocity 15 m/s eastward. To the passengers in the second train, the first train will appear to be moving with a velocity

(A) 5 m/s eastward
(B) 5 m/s westwards
(C) 20 m/s eastward
(D) 20 m/s westwards

Q.14 A thief is running away on a straight road on a jeep moving with a speed of 9 m/s. A police man chases him on a motor cycle moving at a speed of 10 m/s. If the instantaneous separation of jeep from the motor cycle is 100 m, how long will it take for the policeman to catch the thief?

(A) 1 second
(B) 19 seconds
(C) 90 seconds
(D) 100 seconds

RELATIVE MOTION

Q.15 Two cars are moving in the same direction with a speed of 30 km/h. They are separated from each other by 5 km. Third car moving in the opposite direction meets the two cars after an interval of 4 minutes. What is the speed of the third car ?

(A) 30 km/h (B) 35 km/h (C) 40 km/h (D) 45 km/h

Q.16 A bus is moving with a velocity of 10 m/s on a straight road. A scooterist wishes to overtake the bus in 100 s. If the bus is at a distance of 1 km from the scooterist, with what velocity should the scooterist chase the bus ?

(A) 50 m/s (B) 40 m/s (C) 30 m/s (D) 20 m/s

Q.17 A passenger sitting by the window of a train moving with velocity v_1 = 72 km/hr sees for 10 s a train moving with a velocity v_2 = 32.4 km/hr in opposite direction. The length of the second train is

(A) 100 m (B) 110 m (C) 290 m (D) 300 m

Q.18 A train of length 200 m travelling at 30 m/sec overtakes another train of length 300 m travelling at 20 m/sec. The time taken by the first train to pass the second is.

(A) 30 sec. (B) 50 sec. (C) 20 sec. (D) 25 sec.

Q.19 A bus starts to move with an acceleration of 1 m/s^2. A man who is 48 m behind the bus runs to catch the bus with a constant velocity of 10 m/s. In how much time will he catch the bus ?

(A) 10 s (B) 8 s (C) 15 s (D) 11s

ANSWER KEY

LEVEL # 1

Que.	1	2	3	4	5	6
Ans.	B	D	B	A	C	D

LEVEL # 2

Que.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ans.	C	B	B	A,B,D	C	A	C	C	A	A	D	D	B	D	D
Que.	16	17	18	19											
Ans.	D	C	B	B											