PRABHU CLASSES

JEE-MAIN 2020		
Time : 60 Min	**Phy : Subjectwise Paper**	**Marks : 120**

01) A car accelerates from rest at a constant rate α for some time, after which it decelerates at a constant rate β and comes to rest. If the total time elapsed is t, then the maximum velocity acquired by the car is

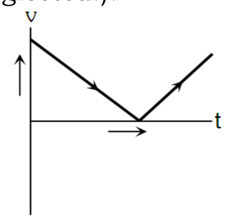
A) $\left(\frac{\alpha^2-\beta^2}{\alpha\beta}\right)t$

B) $\left(\frac{\alpha^2+\beta^2}{\alpha\beta}\right)t$

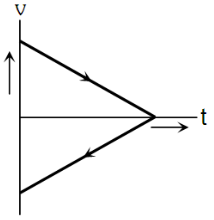
C) $\frac{\alpha\beta\, t}{\alpha+\beta}$

D) $\frac{(\alpha+\beta)t}{\alpha\beta}$

02) A ball is thrown vertically upwards. Which of the following graph represent velocity-time graph of the ball during its flight (Air resistance is neglected.)?



A)



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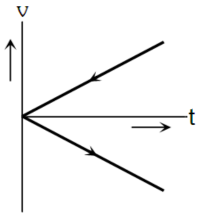
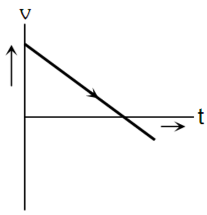
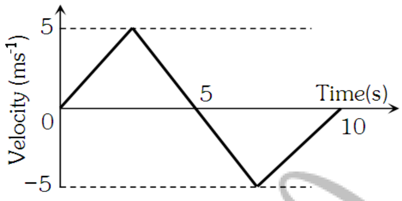


C)



D)

03) The $v-t$ plot of a moving object is shown in the figure. The average velocity of the object during the first 10 seconds is



A) 0
B) 2 m/s
C) 2.5 m/s
D) 5 m/s

04) A body has speed V, 2V and 3V in first 1/3 of distance S, second 1/3 of S and third 1/3 of S respectively. Its average speed will be
A) V
B) 2V
C) $\frac{11}{18}V$
D) $\frac{18}{11}V$

05) Two trains one of length 100 m and another of length 125 m, are moving in mutually opposite directions along parallel lines, meet each other, each with speed 10 m/s. If their acceleration are 0.3 m/s^2 and 0.2 m/s^2 respectively, then the time they take to pass each other will be
A) 20 s
B) 15 s
C) 10 s
D) 5 s

06) The position x of a particle varies with time (t) as $x = at^2 - bt^3$. The acceleration at time t of the particle will be equal to zero, where t=?

A) $\frac{a}{b}$

B) $\frac{2a}{3b}$

C) $\frac{a}{3b}$

D) Zero

07) A body travels 200 cm in the first 2 s and 220 cm in the next 4 s with deceleration. What is the velocity of the body at the end of the seventh second?

A) $20\ cm\ s^{-1}$

B) $10\ cm\ s^{-1}$

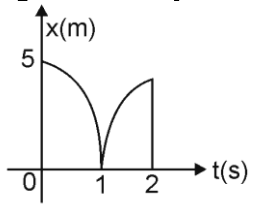
C) $15\ cm\ s^{-1}$

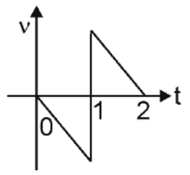
D) $5\ cm\ s^{-1}$

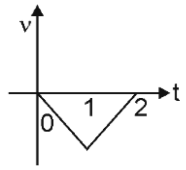
08) A train 100 m long travelling at 40 m s^{-1} starts overtaking another train 200 m long travelling at 30 m s^{-1}. What is the time taken by the first train to pass the second train completely?
A) 30 s
B) 50 s
C) 40 s
D) 20 s

09) A man swimming downstream overcome a float at a point M. After travelling distance D he turned back and passed the float at a distance of D/2 from the point M, then what will be the ratio of speed of swimmer with respect to still water to the speed of the river?
A) 2.5
B) 3
C) 4
D) 2

10) The displacement - time graph of a moving particle with constant acceleration is shown in the figure. Identify the velocity- time graph.




A)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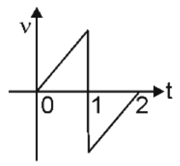
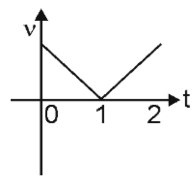

C)


D)

11) Speed of two identical cars are u and 4u at a specific instant. What is the ratio of the respective distances in which the two cars are stopped from that instant?
A) 1 : 1
B) 1 : 8
C) 1 : 4
D) 1 : 16

12) A car starting from rest accelerates at the rate f through a distance S, then continues at constant speed for time t and then decelerates at the rate f/2 to come to rest. If the total distance traversed is 15 S, then what is s?
A) $S = \frac{1}{2} ft^2$
B) $S = \frac{1}{4} ft^2$
C) $S = \frac{1}{6} ft^2$
D) $S = \frac{1}{72} ft^2$

13) The relation between time t and distance x is $t = ax^2 + bx$, where a and b are constants. What is the acceleration?
A) $2av^2$
B) $-2av^3$
C) $2bv^3$
D) $-2abv^2$

14) A parachutist after bailing out falls 50 m without friction. When his parachute opens, it decelerates at 2 m/s^2. He reaches the ground with a speed of 3 m/s. Calculate at what height did he bail out?
A) 243 m
B) 293 m
C) 182 m
D) 91 m

15) An object moving with a speed of 6.25 m/s, is decelerated at a rate given by: $\frac{dv}{dt} = -2.5\sqrt{v}$ where v is the instantaneous speed. What would be the time taken by the object, to come to rest?
A) 5 s
B) 2 s
C) 4 s
D) 8 s

16) A particle is moving on a circular path with constant speed, then its acceleration will be
A) zero.
B) internal radial acceleration.
C) external radial acceleration.
D) constant acceleration.

17) A cyclist goes round a circular path of circumference 34.3 m in $\sqrt{22}$ s. The angle made by him, with the vertical, will be
A) 40^o
B) 42^o
C) 45^o
D) 48^o

18) A particle P is moving in a circle of radius 'a' with a uniform speed v. C is the centre of the circle and AB is a diameter. When passing through B the angular velocity of P about A and C are in the ratio

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

19) The maximum and minimum tension in the string whirling in a circle of radius 2.5 m with constant velocity are in the ratio 5 : 3, then its velocity is
A) $7\ m/s$
B) $\sqrt{4.9}$
C) $\sqrt{98}\ m/s$
D) $\sqrt{490}\ m/s$

20) A body of mass m hangs at one end of a string of length l, the other end of which is fixed. It is given a horizontal velocity so that the string would just reach, where it makes an angle of 60° with the vertical. The tension in the string at mean position is
A) 1 mg
B) 2 mg
C) 3 mg
D) $\sqrt{3}mg$

21) The height y and the distance x along the horizontal plane of a projectile on a certain planet (with no surrounding atmosphere) are given by $y = (8t - 5t^2)$ meter and x = 6t meter, where t is in second, the acceleration due to gravity is given by
A) $2.5\ m/s^2$
B) $5\ m/s^2$
C) $10\ m/s^2$
D) $20\ m/s^2$

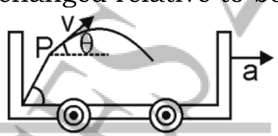
22) The height y and the distance x along the horizontal plane of a projectile on a certain planet (with no surrounding atmosphere) are given by $y = (8t - 5t^2)$ meter and x = 6t meter, where t is in second. The velocity with which the projectile is projected is
A) 6 m/s
B) 8 m/s
C) 10 m/s
D) Not obtainable from the data.

23) A body of mass 0.5 kg is projected under gravity with a speed of 98 m/s at an angle of 30° with the horizontal. The change in momentum (in magnitude) of the body is
A) $24.5\ N-s$
B) $49.0\ N-s$
C) $50.0\ N-s$
D) $98.0\ N-s$

24) A ball is projected upwards from the top of tower with a velocity 50 ms^{-1} making an angle 30° with the horizontal. The height of tower is 70 m. After how many seconds from the instant of throwing will the ball reach the ground?
A) 9 s
B) 7 s
C) 5 s
D) 2 s

25) If the greatest height to which a man can throw a stone is h, then the greatest distance to which he can throw it, will be
A) 3h
B) 2h
C) h
D) $\frac{h}{2}$

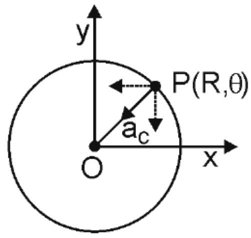
26) A particle is projected from a trolley car with a velocity $\vec{v}$. If the trolley car moves with an acceleration towards right, _________ remain unchanged relative to both ground and trolley car.



A) horizontal velocity
B) maximum range
C) time of flight
D) range

27) A bird is flying towards north with a velocity $40\ km\ h^{-1}$ and a train is moving with velocity $40\ km\ h^{-1}$ towards east. The velocity of the bird noted by a man in the train is
A) $40\sqrt{2}\ km\ h^{-1}$ S-E
B) $40\sqrt{2}\ km\ h^{-1}$ N-E
C) $40\sqrt{2}\ km\ h^{-1}$N-W
D) $40\sqrt{2}\ km\ h^{-1}$ S-W

28) Calculate the acceleration for a particle in uniform circular motion at a point $P(R, \theta)$ on the circle of radius R. (here θ is measured from the x-axis).



A) $-\frac{v^2}{R}\sin\theta\,\hat{i} + \frac{v^2}{R}\cos\theta\,\hat{j}$
B) $-\frac{v^2}{R}\cos\theta\,\hat{i} + \frac{v^2}{R}\sin\theta\,\hat{j}$
C) $-\frac{v^2}{R}\cos\theta\,\hat{i} - \frac{v^2}{R}\sin\theta\,\hat{j}$
D) $\frac{v^2}{R}\hat{i} + \frac{v^2}{R}\hat{j}$

29) A ball of mass m is thrown vertically upwards. Another ball of mass 2m is thrown at an angle θ with the vertical. If both of them stay in air for same period of time, the heights attained by the two balls are in the ratio of

A) 1 : 1

B) $1:\cos\theta$

C) 2 : 1

D) $\cos\theta:1$

30) A car is moving in a circular horizontal track of radius 10 m with a constant speed of 10 m/s. A plumb bob is suspended from the roof of the car by a light rigid rod of length 1.00 m. The angle made by the rod with track is

A) 60^o

B) 45^o

C) 30^o

D) Zero

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Hints and Solutions

01) Ans: **C)** $\frac{\alpha\beta t}{\alpha+\beta}$

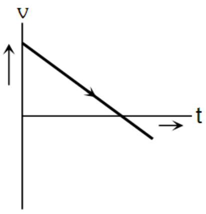
Sol: Consider, the car accelerate at rate α for time t_1, then maximum velocity attained,

$v = 0 + \alpha t_1 = \alpha t_1$

and now, the car decelerates at a rate β for time $(t - t_1)$ and finally comes to rest. Then,

$0 = v - \beta(t - t_1) \Rightarrow 0 = \alpha t_1 - \beta t + \beta t_1$

$\Rightarrow t_1 = \frac{\beta}{\alpha+\beta} t \quad \therefore \quad v = \frac{\alpha\beta}{\alpha+\beta} t$



02) Ans: **D)**

Sol: The velocity decreases linearly (during rise) in the positive region and velocity increases linearly (during fall) in the negative region and the direction is opposite to each other during rise and fall, thus fall is shown in the negative region.

03) Ans: **A)** 0

Sol: As total displacement is zero, the average velocity is also zero.

04) Ans: **D)** $\frac{18}{11}V$

Sol: The average speed,

$$v_{av} = \frac{\text{Total distance}}{\text{Time taken}} = \frac{x}{\frac{x/3}{v} + \frac{x/3}{2v} + \frac{x/3}{3v}} = \frac{18}{11} v$$

05) Ans: **C)** 10 s

Sol: As per given in problem,

Relative velocity of one train w.r.t. other = 10 +10 = 20 m/s.

Relative acceleration = 0.3 + 0.2 = 0.5 m/s^2

If trains cross each other, then from $s = ut + \frac{1}{2}at^2$

As, $s = s_1 + s_2 = 100 + 125 = 225$

$\Rightarrow 225 = 20t + \frac{1}{2} \times 0.5 \times t^2 \Rightarrow 0.5t^2 + 40t - 450 = 0$

$\Rightarrow \quad t = -\frac{40 \pm \sqrt{1600 + 4.(005) \times 450}}{1} = -40 \pm 50$

$\therefore t = 10$ s (Taking +ve value only).

06) Ans: **C)** $\frac{a}{3b}$

Sol: $x = at^2 - bt^3$ So, Velocity $= \frac{dx}{dt} = 2at - 3bt^2$ and

acceleration $= \frac{d^2x}{dt^2} = 2a - 6bt$.

Acceleration will be zero if

$2a - 6bt = 0 \Rightarrow t = \frac{2a}{6b} = \frac{a}{3b}$

07) Ans: **B)** 10 cm s^{-1}

Sol: $200 = u \times 2 - (1/2)a(2)^2$

or $u - a = 100$ ...(i)

$\Rightarrow 200 + 220 = u(2+4) - (1/2)(2+4)^2 a$

or $u - 3a = 70$ ...(ii)

Solving Eqs (i) and (ii), we get $a = 15 \text{ cm s}^{-2}$

and $u = 115 \text{ cm s}^{-1}$

Further, $v = u - at = 115 - 15 \times 7 = 10 \text{ cm s}^{-1}$

08) Ans: **A)** 30 s

Sol: Relative velocity of overtaking

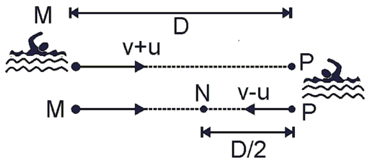
$= 40 - 30 = 10 \text{ m s}^{-1}$.

Total relative distance covered with this relative velocity during overtaking = 100 + 200 = 300m

Thus time taken = 300/10 = 30 s

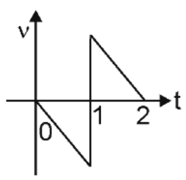
09) Ans: **B)** 3

Sol: Time taken by man to go from M to P and then P to N = time taken by float to go from M to N.



$\Rightarrow \frac{D}{v+u} + \frac{D}{2(v-u)} = \frac{D}{2u}$

Simplify to get $\frac{v}{u} = 3$



10) Ans: **A)**

Sol: At t = 0, slope of the x -t graph is zero; hence velocity is zero at t = 0.

As time increases, slope increases in negative direction; hence velocity increases in negative direction.

At point (1), slope changes suddenly from negative

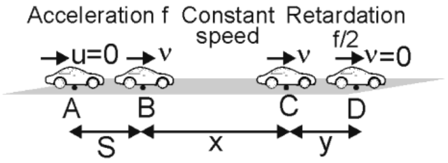
to positive value; hence velocity changes suddenly from negative to positive and then velocity starts decreasing and becomes zero at (2).
Option (a) represents all these clearly.

11) Ans: **D)** 1 : 16
Sol: Assuming constant retardation: using

$v^2 = u^2 + 2as \Rightarrow 0 = u^2 - 2as \quad \text{or} \quad s = \dfrac{u^2}{2a}$

$\text{or } s \propto u^2 \Rightarrow \dfrac{s_1}{s_2} = \dfrac{u_1^2}{u_2^2} \qquad \Rightarrow \dfrac{s_1}{s_2} = \left(\dfrac{u}{4u}\right)^2 = \dfrac{1}{16}$

12) Ans: **D)** $S = \dfrac{1}{72} ft^2$
Sol: Sol: The car starts from point A from rest and moves up to point B with constant acceleration f.



Using $v^2 = u^2 + 2as$, velocity of car at point B,
$v = \sqrt{2fS}$
Car moves distance BC with this constant velocity in time t. using x = vt
$x = \sqrt{2fS}.t \quad ...(i)$
Now the car moves from position C with initial velocity v and moves up to point D with constant retardation.
Again using $v^2 = u^2 + 2as$
So the velocity of car at point C also will be $\sqrt{2fS}$
and finally car stops after covering distance y.
$0^2 = (\sqrt{2fS})^2 - 2\dfrac{f}{2}y$

Distance CD $\Rightarrow y = \dfrac{(\sqrt{2fS})^2}{2(f/2)} = \dfrac{2fS}{f} = 2S \quad ...(ii)$

So, the total distance $AD = AB + BC + CD = 15S$
(given) $\Rightarrow S + x + 2S = 15S \Rightarrow x = 12S$
Substituting the value of x in equation (i) we get
$x = \sqrt{2fS}.t \Rightarrow 12S = \sqrt{2fS}.t \Rightarrow 144S^2 = 2fS.t^2$

Thus, $S = \dfrac{1}{72}ft^2$

13) Ans: **B)** $-2av^3$
Sol: We are given the relation between time and distance as $t = \alpha x^2 + \beta x \quad ...(i)$
Differentiating equation (i) w.r.t. 'x', we get
$\dfrac{dt}{dx} = 2\alpha x + \beta$ but $\dfrac{dt}{dx} = v \Rightarrow v = \dfrac{1}{2\alpha x + \beta} \quad ...(ii)$
Differentiating equation (ii) w.r.t. 't', we get
acceleration i.e. $a = \dfrac{dv}{dt} = \dfrac{dv}{dx}.\dfrac{dx}{dt}$

$\therefore a = v\dfrac{dv}{dx} = \dfrac{-v.2\alpha}{(2\alpha x + \beta)^2} = -2\alpha.v.v^2 = -2\alpha v^3$

14) Ans: **B)** 293 m
Sol: After bailing out from position A, parachutist fall freely under gravity a distance 50 m.
Let the velocity acquired by him at position B be 'v'
$\Rightarrow v^2 = u^2 + 2as = 0 + 2 \times 9.8 \times 50 = 980$
(As $u = 0, a = 9.8\ m/s^2, s = 50\ m$)
At position B, parachute opens and it moves with retardation of $2\ m/s^2$ and reach at ground (position C) with velocity of 3 m/s.
For the journey of the part 'BC' again applying the equation $v^2 = u^2 + 2as$, where $v = 3\ m/s$,
$u = \sqrt{980}\ m/s, a = -2\ m/s^2, s = h$
$\therefore (3)^2 = (\sqrt{980})^2 + 2 \times (-2) \times h \Rightarrow 9 = 980 - 4h$
$\therefore h = \dfrac{980 - 9}{4} = \dfrac{971}{4} = 242.7 = 243\ m$
Thus, the total height by which parachutist bailed out $= 50 + 243 = 293 m.$

15) Ans: **B)** 2 s
Sol: We are given $\dfrac{dv}{dt} = -0.25\sqrt{v}$

or $\dfrac{1}{\sqrt{v}} dv = -2.5$

On integrating, within limit (at $t = 0, v_1 = 6.25\ m\ s^{-1}$ and at any time, $v_2 = 0$), we get

$\int_{6.25\ m\ s^{-1}}^{0} v^{-1/2} dv = -2.5\int_0^t dt$

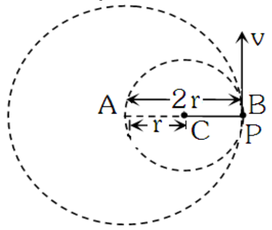
$\Rightarrow 2 \times [v^{1/2}]^0_{6.25} = -(2.5)t \quad \Rightarrow t = \dfrac{-2 \times (6.25)^{1/2}}{-2.5} = 2\ s$

16) Ans: **B)** internal radial acceleration.
Sol: Acceleration causes due to change in direction, in uniform circular motion and is directed radially towards centre.

17) Ans: **C)** 45°
Sol: Given, $2\pi r = 34.3$
$\Rightarrow r = \dfrac{34.3}{2\pi}$ and $v = \dfrac{2\pi r}{T} = \dfrac{2\pi r}{\sqrt{22}}$

$\therefore$ Angle of binding i.e. $\theta = \tan^{-1}\left(\dfrac{v^2}{rg}\right) = 45^\circ$

18) Ans: **C)** 1 : 2



Sol:
From the above figure,
Angular velocity of particle P about point A,
$\omega_A = \dfrac{v}{r_{AB}} = \dfrac{v}{2r}$
Angular velocity of particle P about point C,

$\omega_C = \frac{v}{r_{BC}} = \frac{v}{r}$ By solving, $\frac{\omega_A}{\omega_C} = \frac{v/2r}{v/r} = \frac{1}{2}$.

19) Ans: **C)** $\sqrt{98}$ m/s

Sol: Let us assume, that though particle moving in a vertical loop, but its speed remain constant.

$\therefore$ Tension at lowest point $T_{max} = \frac{mv^2}{r} + mg$

and Tension at highest point $T_{min} = \frac{mv^2}{r} - mg$

$$\frac{T_{max}}{T_{min}} = \frac{\frac{mv^2}{r} + mg}{\frac{mv^2}{r} - mg} = \frac{5}{3}$$

Now solving, $v = \sqrt{4gr} = \sqrt{4 \times 9.8 \times 2.5} = \sqrt{98}$ m/s

20) Ans: **B)** 2 mg

Sol: As the body is released from the position p (inclined at angle θ from vertical), then velocity at mean position $v = \sqrt{2gl(1 - \cos\theta)}$

Thus, Tension at the lowest point = $mg + \frac{mv^2}{l}$

$= mg + \frac{m}{l}[2gl(1 - \cos 60)] = mg + mg = 2\ mg$

21) Ans: **C)** $10\ m/s^2$

Sol: The horizontal and vertical components of acceleration are respectively,

$a_x = \frac{d}{dt}(v_x) = 0$, $a_y = \frac{d}{dt}(v_y) = -10\ m/s^2$

$\therefore$ Net acceleration a = $\sqrt{a_x^2 + a_y^2}$

$\Rightarrow = \sqrt{0^2 + 10^2}$ = 10 m/s²

22) Ans: **C)** 10 m/s

Sol: From the given equations,

$v_y = \frac{dy}{dt} = 8 - 10t$, $v_x = \frac{dx}{dt} = 6$

$\therefore$ At the time of projection, $v_y = \frac{dy}{dt} = 8$ and

$v_x = 6$

$\therefore v = \sqrt{v_x^2 + v_y^2} = \sqrt{6^2 + 8^2} = 10$ m/s

23) Ans: **B)** 49.0 N – s

Sol: Here, Change in momentum = $2mu\sin\theta$

= $2 \times 0.5 \times 98 \times \sin 30$ = 45 N – s

24) Ans: **B)** 7 s

Sol: From the given information in the problem, The vertical component of velocity of projection $= -50 \sin 30^\circ = -25$ m/s

If t be the time taken to reach the ground,

$h = ut + \frac{1}{2}gt^2 \Rightarrow 70 = -25t + \frac{1}{2} \times 10t^2$

$\Rightarrow 70 = -25t + 5t^2 \Rightarrow t^2 - 5t - 14 = 0$

$\Rightarrow$ t = - 2s and 7s

As, t =- 2 s is not valid $\therefore$ t = 7 s

25) Ans: **B)** 2h

Sol: For greatest height θ = 90°

Given that, $H_{max} = \frac{u^2 \sin^2(90^\circ)}{2g} = \frac{u^2}{2g} = h$

$\therefore R_{max} = \frac{u^2 \sin^2 2(45^\circ)}{g} = \frac{u^2}{g} = 2h$

26) Ans: **C)** time of flight

Sol: Vertical component of projectile relative to trolley.

$v_{yT} = v\sin\theta$ and vertical component of projectile relative to ground.

$v_{yG} = v\sin\theta$ Vertical component is unchanged relative to trolley and ground

Now time of flight $= \frac{2u\sin\theta}{g}$

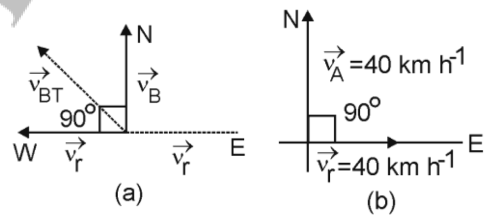
Time of flight remains unchanged relative to trolley and ground.

So, right choice is (c).

27) Ans: **C)** $40\sqrt{2}$ km h^{-1}N-W

Sol: To find the relative velocity of bird w.r.t. train, superimpose velocity $-\vec{v}T$ on both objects.

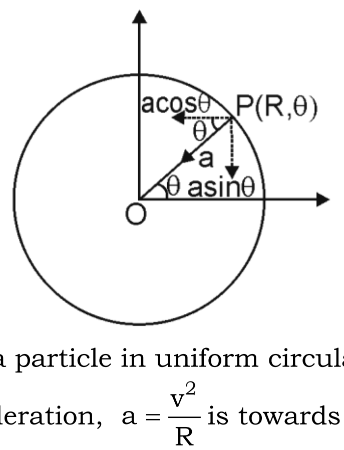
Now as a result of it, the train is at rest, while the bird possesses two velocities, $\vec{v}B$ towards north and $-\vec{v}T$ along west.



$|\vec{v}BT| = \sqrt{|\vec{v}B|^2 + |-\vec{v}T|^2}$ [By formula $\theta = 90^0$]

$= \sqrt{40^2 + 40^2} = 40\sqrt{2}$ km h^{-1} north - west

28) Ans: **C)** $-\frac{v^2}{R}\cos\theta\,\hat{i} - \frac{v^2}{R}\sin\theta\,\hat{j}$



Sol:

For a particle in uniform circular motion,

acceleration, $a = \frac{v^2}{R}$ is towards the centre.

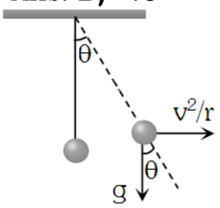
From figure, we have $\vec{a} = -a\cos\theta\,\hat{i} - a\sin\theta\,\hat{j}$

$$\Rightarrow \vec{a} = -\frac{v^2}{R}\cos\theta\hat{i} - \frac{v^2}{R}\sin\theta\,\hat{j}$$

29) Ans: **A)** 1 : 1
Sol: The vertical components of velocity of both the balls will be same, when they stay in air for the same period of time. Thus, vertical height attained will be same.

30) Ans: **B)** 45°

Sol:



From the figure, $\tan\theta = \frac{v^2/r}{g} = \frac{v^2}{rg}$

$$\therefore\ \theta = \tan^{-1}\left(\frac{v^2}{rg}\right) = \tan^{-1}\left(\frac{10\times10}{10\times10}\right) = \tan^{-1}(1) = 45^\circ$$