DPP - Daily Practice Problems

Name :

Date :

Start Time :

End Time :

PHYSICS 08

SYLLABUS : MOTION IN A PLANE-3 (Vertical Circular Motion, Relative Motion)

Max. Marks : 112 **Time : 60 min.**

GENERAL INSTRUCTIONS

- The Daily Practice Problem Sheet contains 28 MCQ's. For each question only one option is correct. Darken the correct circle/ bubble in the Response Grid provided on each page.
- You have to evaluate your Response Grids yourself with the help of solution booklet.
- Each correct answer will get you 4 marks and 1 mark shall be deduced for each incorrect answer. No mark will be given/ deducted if no bubble is filled. Keep a timer in front of you and stop immediately at the end of 60 min.
- The sheet follows a particular syllabus. Do not attempt the sheet before you have completed your preparation for that syllabus. Refer syllabus sheet in the starting of the book for the syllabus of all the DPP sheets.
- After completing the sheet check your answers with the solution booklet and complete the Result Grid. Finally spend time to analyse your performance and revise the areas which emerge out as weak in your evaluation.

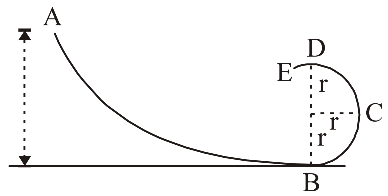
DIRECTIONS (Q.1-Q.19) : There are 19 multiple choice questions. Each question has 4 choices (a), (b), (c) and (d), out of which **ONLY ONE** choice is correct.

Q.1 A man whirls a stone round his head on the end of a string 4.0 metre long. Can the string be in a horizontal, plane? If the stone has a mass of 0.4 kg and the string will break, if the tension in it exceeds 8 N. The smallest angle the string can make with the horizontal and the speed of the stone will respectively be (Take $g = 10\ m/sec^2$)

(a) 30º, 7.7 m/s (b) 60º, 7.7 m/s

(c) 45º, 8.2 m/s (d) 60º, 8.7 m/s

Q.2 In figure ABCDE is a channel in the vertical plane, part BCDE being circular with radius r. A ball is released from A and slides without friction and without rolling. It will complete the loop path when



(a) $h > 5\ r/2$ (b) $h < 5\ r/2$

(c) $h < 2r/5$ (d) $h > 2r/5$

Q.3 An aircraft loops the loop of radius R = 500 m with a constant velocity v = 360 km/h. The weight of the flyer of mass m = 70 kg in the lower, upper and middle points of the loop will respectively be-

(a) 210 N, 700 N, 1400 N (b) 1400 N, 700 N, 2100 N

(c) 700 N, 1400 N, 210 N (d) 2100 N, 700 N, 1400 N

RESPONSE GRID	1. ⓐⓑⓒⓓ	2. ⓐⓑⓒⓓ	3. ⓐⓑⓒⓓ

Space for Rough Work

Q.4 A particle of mass 3 kg is moving under the action of a central force whose potential energy is given by $U(r) = 10r^3$ joule. For what energy and angular momentum will the orbit be a circle of radius 10 m ?
(a) 2.5×10^4 J, 3000 kgm^2/sec
(b) 3.5×10^4 J, 2000 kgm^2/sec
(c) 2.5×10^3 J, 300 kgm^2/sec
(d) 3.5×10^3 J, 300 kgm^2/sec

Q.5 A string of length 1 m is fixed at one end and carries a mass of 100 gm at the other end. The string makes $2/\pi$ revolutions per second about a vertical axis through the fixed end. The angle of inclination of the string with the vertical, and the linear velocity of the mass will respectively be - (in M.K.S. system)
(a) 52°14', 3.16 (b) 50°14', 1.6
(c) 52°14', 1.6 (d) 50°14', 3.16

Q.6 A particle of mass m is moving in a circular path of constant radius r such that its centripetal acceleration a_c is varying with time t as $a_c = k^2rt^2$, where k is a constant. The power delivered to the particle by the force acting on it will be -
(a) mk^2t^2r (b) $mk^2r^2t^2$ (c) $m^2k^2t^2r^2$ (d) mk^2r^2t

Q.7 A car is moving in a circular path of radius 100 m with velocity of 200 m/sec such that in each sec its velocity increases by 100 m/s, the net acceleration of car will be - (in m/sec)
(a) $100\sqrt{17}$ (b) $10\sqrt{7}$ (c) $10\sqrt{3}$ (d) $100\sqrt{3}$

Q.8 A 4 kg balls is swing in a vertical circle at the end of a cord 1 m long. The maximum speed at which it can swing if the cord can sustain maximum tension of 163.6 N will be -
(a) 6 m/s (b) 36 m/s (c) 8 m/s (d) 64 m/s

Q.9 The string of a pendulum is horizontal. The mass of the bob is m. Now the string is released. The tension in the string in the lowest position is -
(a) 1 mg (b) 2 mg (c) 3 mg (d) 4 mg

Q.10 A swimmer can swim in still water at a rate 4 km/h. If he swims in a river flowing at 3 km/h and keeps his direction (w.r.t. water) perpendicular to the current. Find his velocity w.r.t. the ground.
(a) 3 km/hr (b) 5 km/hr
(c) 4 km/hr (d) 7 km/hr

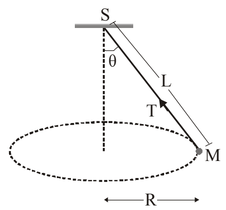
Q.11 The roadway bridge over a canal is the form of an arc of a circle of radius 20 m. What is the minimum speed with which a car can cross the bridge without leaving contact with the ground at the highest point ($g = 9.8$ m/s^2)
(a) 7 m/s (b) 14 m/s (c) 289 m/s (d) 5 m/s

Q.12 A cane filled with water is revolved in a vertical circle of radius 0.5 m and the water does not fall down. The maximum period of revolution must be -
(a) 1.45 (b) 2.45 (c) 14.15 (d) 4.25

Q.13 A particle of mass m slides down from the vertex of semi-hemisphere, without any initial velocity. At what height from horizontal will the particle leave the sphere-
(a) $\frac{2}{3}R$ (b) $\frac{3}{2}R$ (c) $\frac{5}{8}R$ (d) $\frac{8}{5}R$

Q.14 A body of mass m tied at the end of a string of length ℓ is projected with velocity $\sqrt{4\ell g}$, at what height will it leave the circular path -
(a) $\frac{5}{3}\ell$ (b) $\frac{3}{5}\ell$ (c) $\frac{1}{3}\ell$ (d) $\frac{2}{3}\ell$

Q.15 A string of length L is fixed at one end and carries a mass M at the other end. The string makes $2/\pi$ revolutions per second around the vertical axis through the fixed end as shown in the figure, then tension in the string is
(a) ML
(b) 2 ML
(c) 4 ML
(d) 16 ML



Q.16 A train has to negotiate a curve of radius 400 m. By how much should the outer rail be raised with respect to inner rail for a speed of 48 km/hr. The distance between the rails is 1 m.
(a) 12 m (b) 12 cm
(c) 4.5 cm (d) 4.5 m

RESPONSE GRID					
	4. ⓐⓑⓒⓓ	5. ⓐⓑⓒⓓ	6. ⓐⓑⓒⓓ	7. ⓐⓑⓒⓓ	8. ⓐⓑⓒⓓ
	9. ⓐⓑⓒⓓ	10. ⓐⓑⓒⓓ	11. ⓐⓑⓒⓓ	12. ⓐⓑⓒⓓ	13. ⓐⓑⓒⓓ
	14. ⓐⓑⓒⓓ	15. ⓐⓑⓒⓓ	16. ⓐⓑⓒⓓ		

Space for Rough Work

Q.17 A ship is steaming towards east at a speed of 12 ms^{-1}. A woman runs across the deck at a speed of 5 ms^{-1} in the direction at right angles to the direction of motion of the ship i.e. towards north. What is the velocity of the woman relative to sea ?

(a) 13 m/s (b) 5 m/s (c) 12 m/s (d) 17 m/s

Q.18 A man is walking on a level road at a speed of 3 km/h. Raindrops fall vertically with a speed of 4 km/h. Find the velocity of raindrops with respect to the men.

(a) 3 km/hr (b) 4 km/hr (c) 5 km/hr (d) 7 km/hr

Q.19 A stone of mass 1 kg tied to a light inextensible string of length $L = \frac{10}{3}$ m is whirling in a circular path of radius L in a vertical plane. If the ratio of the maximum tension in the string to the minimum tension in the string is 4 and if g is taken to be 10m / sec^2, the speed of the stone at the highest point of the circle is

(a) 20 m/sec (b) $10\sqrt{3}$m/sec

(c) $5\sqrt{2}$m/sec (d) 10 m/sec

DIRECTIONS (Q.20-Q.22) : In the following questions, more than one of the answers given are correct. Select the correct answers and mark it according to the following codes:

Codes :

(a) 1, 2 and 3 are correct **(b)** 1 and 2 are correct

(c) 2 and 4 are correct **(d)** 1 and 3 are correct

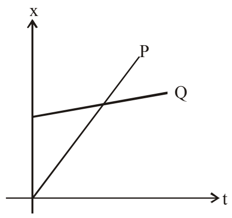
Q.20 Two bodies P and Q are moving along positive x-axis their position-time graph is shown below. If $\vec{V}_{PQ}$ is velocity of P w.r.t. Q and $\vec{V}_{QP}$ is velocity of Q w.r.t P, then

(1) $|\vec{V}_{PQ}| = |\vec{V}_{QP}|$ = constant

(2) $\vec{V}_{PQ}$ towards origin

(3) $\vec{V}_{QP}$ towards origin

(4) $|\vec{V}_{PQ}| \neq |\vec{V}_{QP}|$ = constant



Q.21 A swimmer who can swim in a river with speed mv (with respect to still water) where v is the velocity of river current, jumps into the river from one bank to cross the river. Then

(1) If m < 1 he cannot cross the river

(2) If m ≤ 1 he cannot reach a point on other bank directly opposite to his starting point.

(3) If m > 1 he can reach a point on other bank

(4) He can reach the other bank at some point, whatever be the value of m.

Q.22 Consider two children riding on the merry-go-round Child 1 sits near the edge, Child 2 sits closer to the centre. Let v_1 and v_2 denote the linear speed of child 1 and child 2, respectively. Which of the following is/are wrong ?

(1) We cannot determine v_1 & v_2 without more information

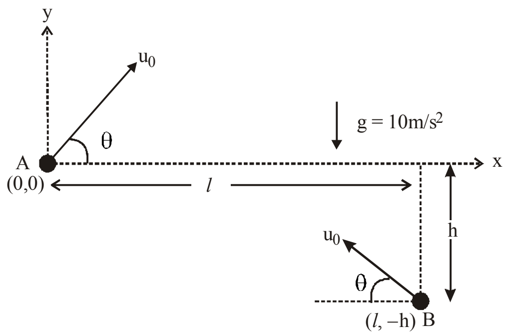
(2) $v_1 = v_2$

(3) $v_1 < v_2$

(4) $v_1 > v_2$

DIRECTIONS (Q.23-Q.25) : Read the passage given below and answer the questions that follows :

Three of the fundamental constants of physics are the universal gravitational constant, $G = 6.7 \times 10^{-11} m^3kg^{-1}s^{-2}$, the speed of light, $c = 3.0 \times 10^8$ m/s, and Planck's constant, $h = 6.6 \times 10^{-34}$ Js^{-1}. Two particles A and B are projected in the vertical plane with same initial velocity u_0 from part (0, 0) and (ℓ, –h) towards each other as shown in figure at t = 0.



RESPONSE GRID				
17. ⓐⓑⓒⓓ	18. ⓐⓑⓒⓓ	19. ⓐⓑⓒⓓ	20. ⓐⓑⓒⓓ	21. ⓐⓑⓒⓓ
22. ⓐⓑⓒⓓ				

Space for Rough Work

Q.23 The path of particle A with respect to particle B will be –
(a) parabola
(b) straight line parallel to x-axis
(c) straight line parallel to y-axis
(d) None of these

Q.24 Minimum distance between particle A and B during motion will be –
(a) ℓ (b) h
(c) $\sqrt{\ell^2 + h^2}$ (d) $\ell + h$

Q.25 The time when separation between A and B is minimum is
(a) $\frac{x}{u_0 \cos\theta}$ (b) $\sqrt{\frac{2h}{g}}$
(c) $\frac{\ell}{2u_0 \cos\theta}$ (d) $\frac{2\ell}{u_0 \cos\theta}$

DIRECTIONS (Qs. 26-Q.28) : Each of these questions contains two statements: Statement-1 (Assertion) and Statement-2 (Reason). Each of these questions has four alternative choices, only one of which is the correct answer. You have to select the correct choice.

(a) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(b) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1.
(c) Statement-1 is False, Statement-2 is True.
(d) Statement-1 is True, Statement-2 is False.

Q.26 Statement-1 : The relative velocity between any two bodies moving in opposite direction is equal to sum of the velocities of two bodies.

Statement-2 : Sometimes relative velocity between two bodies is equal to difference in velocities of the two.

Q.27 Statement-1: A river is flowing from east to west at a speed of 5m/min. A man on south bank of river, capable of swimming 10 m/min in still water, wants to swim across the river in shortest time. He should swim due north.

Statement-2 : For the shortest time the man needs to swim perpendicular to the bank.

Q.28 Statement-1 : Rain is falling vertically downwards with velocity 6 km/h. A man walks with a velocity of 8 km/h. Relative velocity of rain w.r.t. the man is 10 km/h.
Statement-2 : Relative velocity is the ratio of two velocities.

RESPONSE GRID	
	23. ⓐⓑⓒⓓ 24. ⓐⓑⓒⓓ 25. ⓐⓑⓒⓓ 26. ⓐⓑⓒⓓ 27. ⓐⓑⓒⓓ
	28. ⓐⓑⓒⓓ

DAILY PRACTICE PROBLEM SHEET 8 - PHYSICS			
Total Questions	28	Total Marks	112
Attempted		Correct	
Incorrect		Net Score	
Cut-off Score	28	Qualifying Score	44
Success Gap = Net Score – Qualifying Score			
Net Score = (Correct × 4) – (Incorrect × 1)			

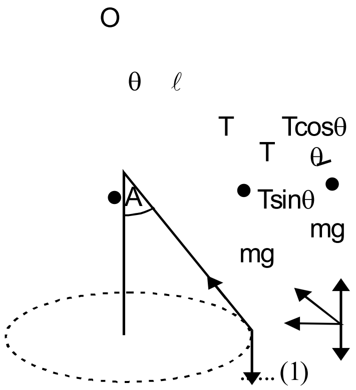
Space for Rough Work

DAILY PRACTICE PROBLEMS

PHYSICS SOLUTIONS

08

(1) **(a).**



Form figure

$T\cos\theta = mg$ ..... (1)

$T\sin\theta = \frac{mv^2}{r} = \frac{mv^2}{\ell\sin\theta}$ ...... (2)

Form eq. (1), $T = \frac{mg}{\cos\theta}$

When the string is horizontal, θ must be 90º i.e.,cos 90º = 0

$\therefore\ T = \frac{mg}{0} = \infty$

Thus the tension must be infinite which is impossible, so the string can not be in horizontal plane.

The maximum angle θ is given by the breaking tension of the string in the equation T cos θ = m.g

Here T (Maximum) = 8 N and m = 0.4 kg

$\therefore\ 8\cos\theta = 0.4 \times g = 0.4 \times 10 = 4$

$\cos\theta = (4/8) = \frac{1}{2}, \theta = 60^\circ$

The angle with horizontal = 90º – 60º = 30º

From equation (2), $8\sin 60^\circ = \frac{0.4 \times v^2}{4\sin 60^\circ}$

$v^2 = \frac{32\sin^2 60^\circ}{0.4} = 80\sin^2 60^\circ$

$\Rightarrow v = \sqrt{80}\ \sin 60^\circ = 7.7$ m/sec

(2) **(a).** Let m be the mass of the ball. When the ball comes down to B, its potential energy mgh which is converted into kinetic energy. Let v_B, be the velocity of the ball at B.

Then, $mgh = \frac{1}{2} m v_B^2$

The ball now rises to a point D, where its potential energy is mg(h – 2r). If v_D be the velocity of the ball at D, then,

$mg(h-2r) = \frac{1}{2} m v_D^2$ ......(2)

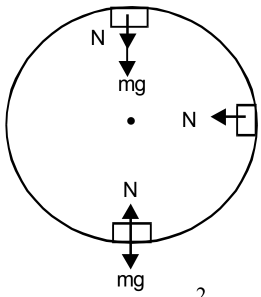
Now to complete the circular path, it is necessary that the centrifugal force acting upward at point D, should be equal or greater than the force mg acting downward at point D should be equal or greater than the force mg acting downward. Therefore

$\frac{m v_D^2}{r} \geq mg$ or $v_D^2 \geq rg$

From equation (2) $v_D^2 = 2g(h-2r)$,

$\therefore 2g(h-2r) \geq rg \Rightarrow h \geq \frac{5}{2} r$

(3) **(d).** See fig, Here v = 360 km/hr = 100 m/sec



At lower point, $N - mg = \frac{mv^2}{R}$,

N = weight of the flyer $= mg + \frac{mv^2}{R}$

$N = 70 \times 10 + \frac{70 \times (10000)}{500} = 2100$ N

At upper point, $N + mg = \frac{mv^2}{R}$,

$N = \frac{mv^2}{R} - mg = 1400 - 700 = 700$ N

At middle point, $N = \frac{mv^2}{R} = 1400$ N

(4) **(a).** Given that $U(r) = 10r^3$

So the force F acting on the particle is given by,

$F = -\frac{\partial U}{\partial r} = -\frac{\partial}{\partial r}(10r^3) = -10 \times 3r^2 = -30r^2$

For circular motion of the particle,

$F = \frac{mv^2}{r} = 30r^2$

Substituting the given values, we have,

$\frac{3 \times v^2}{10} = 30 \times (10)^2$ or $v = 100$ m/s

The total energy in circular motion

$E = K.E. + P.E. = \frac{1}{2}mv^2 + U(r)$

$= \frac{1}{2} \times 3 \times (100)^2 + 10 + (10)^3 = 2.5 \times 10^4$ joule

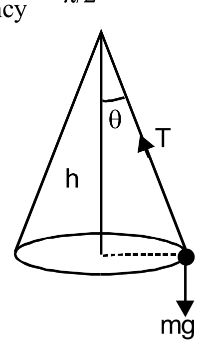
Angular momentum

$= mvr = 3 \times 100 \times 10 = 3000$ kg–m²/sec

Also time period $T = \frac{2\pi r}{v} = \frac{2 \times \pi \times 10}{100} = \frac{\pi}{5}$ sec

(5) **(a).** Let T be the tension, θ the angle made by the string with the vertical through the point of suspension.

The time period $t = 2\pi\sqrt{\frac{h}{g}} = \frac{1}{\text{frequency}} = \pi/2$



Therefore $\omega = \sqrt{\frac{g}{h}} = 4 \Rightarrow \frac{h}{g} = \frac{1}{16}$

$\cos\theta = \frac{h}{\ell} = \frac{g}{16}$

$= 0.6125 \Rightarrow \theta = 52^\circ\ 14'$

Linear velocity

$= (\ell \sin\theta)\omega = 1 \times \sin 52^\circ\ 14' \times 4$

$= 3.16$ m/s

(6) **(d).** Centripetal acceleration, $a_c = \frac{v^2}{r} = k^2rt^2$

$\therefore$ Variable velocity $v = \sqrt{k^2r^2t^2} = krt$

The force causing the velocity to varies

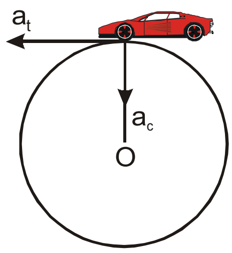
$F = m\frac{dv}{dt} = mkr$

The power delivered by the force is,

$P = Fv = mkr \times krt = mk^2r^2t$

(7) **(a).** We know centripetal acceleration

$a_c = \frac{(\text{tangential velocity})^2}{\text{radius}} = \frac{(200)^2}{100} = 400\ \text{m/sec}^2$



Tangential acceleration

$a_t = 100$ m/sec² (given)

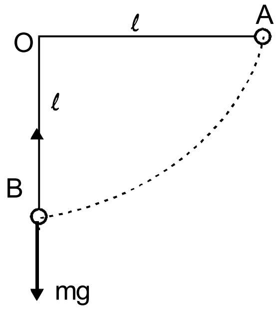
$\therefore a_{net} = \sqrt{a_c^2 + a_t^2 + 2a_ca_t\cos 90^\circ} = \sqrt{a_c^2 + a_t^2}$

$= \sqrt{(400)^2 + (100)^2} = 100\sqrt{17}$ m/s²

(8) **(b).** Suppose v be the velocity of particle at the lowest position B.

According to conservation of energy

(K.E. + P.E.) at A = (K.E. + P.E.) at B



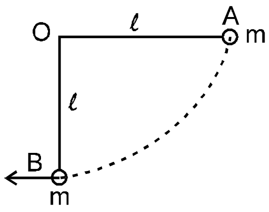
$\Rightarrow 0 + mg\ell = \frac{1}{2}mv^2 + 0 \Rightarrow v = \sqrt{2g\ell}$

(9) **(a).** Maximum tension $T = \frac{mv^2}{r} + mg$

$\therefore \frac{mv^2}{r} = T - mg$

or $\frac{mv^2}{r} = 163.6 - 4 \times 9.8 \Rightarrow v = 6$ m/s

(10) **(c).** The situation is shown in fig. Let v be the velocity of the bob at the lowest position. In this position the P.E. of bob is converted into K.E. hence -



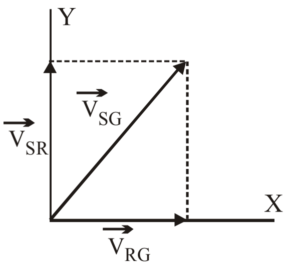
$mg\ell = \frac{1}{2}mv^2 \Rightarrow v^2 = 2g\ell$ ....(1)

If T be the tension in the string,

then $T - mg = \frac{mv^2}{\ell}$ ....(2)

From (1) & (2), T = 3 mg

(11) **(b).** The velocity of the swimmer w.r.t. water $\vec{v}_{SR} = 4.0$ km/h in the direction perpendicular to the river. The velocity of river w.r.t. the ground is $\vec{v}_{RG} = 3.0$ km/h along the length of river.



The velocity of the swimmer w.r.t. the ground is $\vec{v}_{SG}$ where

$$\vec{V}_{SG} = \vec{V}_{SR} + \vec{V}_{RG}$$

$$V_{SG} = \sqrt{V_{SR}^2 + V_{RG}^2} = \sqrt{4^2 + 3^2}$$

$$= \sqrt{16+9} = \sqrt{25} = 5 \text{ km/hr}$$

(12) **(b).** The minimum speed at highest point of a vertical circle is given by $v_c = \sqrt{rg} = \sqrt{20 \times 9.8} = 14$ m/s

(13) **(a).** The speed at highest point must be

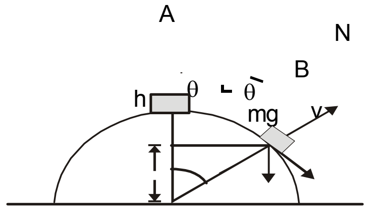
$$v > \sqrt{gr}, \; v = r\omega = r\frac{2\pi}{T}$$

$$\therefore \; r\frac{2\pi}{T} > \sqrt{rg}$$

$$T < \frac{2\pi r}{\sqrt{rg}} < 2\pi\sqrt{\frac{r}{g}} < 2\pi\sqrt{\frac{0.5}{9.8}} < 1.4 \text{ sec}$$

Maximum period of revolution = 1.4 sec

(14) **(a).** Let the particles leaves the sphere at height h,



$$\frac{mv^2}{R} = mg\cos\theta - N$$

When the particle leaves the sphere i.e. N = 0

$$\frac{mv^2}{R} = mg\cos\theta$$

$\Rightarrow v^2 = gR\cos\theta$ ....(1)

According to law of conservation of energy

(K.E. + P.E.) at A = (K.E. + P.E.) at B

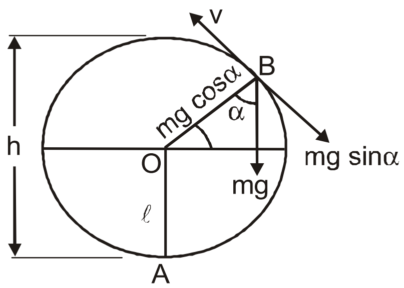
$$\Rightarrow 0 + mgR = \frac{1}{2}mv^2 + mgh$$

$\Rightarrow v^2 = 2g(R - h)$ ....(2)

From (1) & (2), $h = \frac{2}{3}R$

Also $\cos\theta = \frac{2}{3}$

(15) **(a).** Let the body will have the circular path at height h above the bottom of circle from figure



$$\frac{mv^2}{\ell} = T + mg\cos\alpha$$

On leaving the circular path

T = 0

$$\therefore \frac{mv^2}{\ell} = mg\cos\alpha$$

$\Rightarrow v^2 = g\,\ell\cos\alpha$ ....(1)

According to law of conservation of energy

(K.E. + P.E.) at A = (K.E. + P.E.) at B

$$\Rightarrow 0 + 2mg\ell = \frac{1}{2}mv^2 + mgh$$

$\Rightarrow v^2 = 2g(2\ell - h)$ ....(2)

From (1) & (2) $h = \frac{5}{3}\ell$

Also, $\cos\alpha = \frac{h - \ell}{\ell}$

(16) **(d)** $T\sin\theta = M\omega^2 R$

$T\sin\theta = M\omega^2 L\sin\theta$

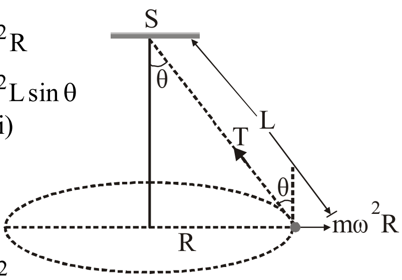
From (i) and (ii)

$T = M\omega^2 L$

$= M4\pi^2 n^2 L$

$= M4\pi^2\left(\frac{2}{\pi}\right)^2 L$

$= 16$ ML



(17) **(a).** $v = 60$ km/hr $= \frac{50}{3}$ m/s

r = 0.1 km = 100m

$$\therefore \tan\theta = \frac{v^2}{rg} = 0.283$$

$$\therefore \theta = \tan^{-1}(0.283)$$

(18) **(c).** We know that $\tan\theta = \frac{v^2}{rg}$ ..... (1)

Let h be the relative raising of outer rail with respect to inner rail. Then

$\tan\theta = \frac{h}{\ell}$ ...... (2)

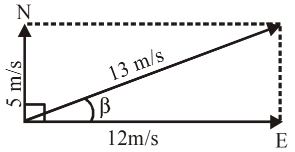
(ℓ = separation between rails)

From (1) & (2), $h = \frac{v^2}{rg} \times \ell$

Hence $v = 48$ km/hr $= \frac{120}{9}$ m/s, (r = 400 m, ℓ = 1m),

$$\therefore h = \frac{(120/9)^2 \times 1}{400 \times 9.8} = 0.045 \text{ m} = 4.5 \text{ cm}$$

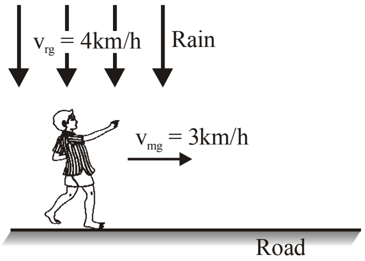
(19) **(a).** The woman has two velocities simultaneously while running on the deck, one velocity is equal to the velocity of ship i.e. 12 m/s due east and other velocity is 5 m/s due north.



The resultant velocity of woman

$$= \sqrt{(12)^2 + (5)^2} = 13 \text{ m/s}$$

(20) **(c).** If we consider velocity of rain with respect to the man is V km/h.

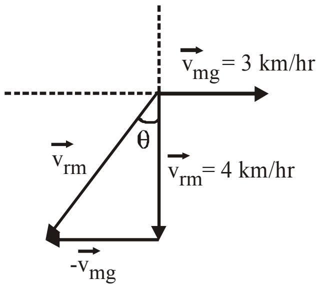


Relative velocity of man w.r.t. ground

$$\vec{v}_{mg} = \vec{v}_m - \vec{v}_g \quad ....(1)$$

Velocity of rain w.r.t. ground

$$\vec{v}_{rg} = \vec{v}_r - \vec{v}_g \quad ....(2)$$



Velocity of rain w.r.t. man $\vec{v}_{rm} = \vec{v}_r - \vec{v}_m$

On subtracting eq^n. 1 from eq^n. 2

$$\vec{v}_{rm} = \vec{v}_{rg} - \vec{v}_{mg}$$

$$|v_{rm}| = \sqrt{v_{rg}{}^2 + v_{mg}{}^2} = \sqrt{4^2 + 3^2} = 5 \text{ km/hr}$$

(21) **(d)** Since the maximum tension T_B in the string moving in the vertical circle is at the bottom and minimum tension T_T is at the top.

$$\therefore \quad T_B = \frac{mv_B^2}{L} + mg \text{ and } T_T = \frac{mv_T^2}{L} - mg$$

$$\therefore \quad \frac{T_B}{T_T} = \frac{\frac{mv_B^2}{L}}{\frac{mv_T^2}{L} - mg} = \frac{4}{1} \text{ or } \frac{v_B^2 + gL}{v_T^2 - gL} = \frac{4}{1}$$

$$\text{or} \quad v_B^2 + gL = 4v_T^2 - 4gL \text{ but } v_B^2 = v_T^2 + 4gL$$

$$\therefore \quad v_T^2 + 4gL + gL = 4v_T^2 - 4gL \Rightarrow 3v_T^2 = 9gL$$

$$\therefore \quad v_T^2 = 3 \times g \times L = 3 \times 10 \times \frac{10}{3} \text{ or } v_T = 10 \text{m/sec}$$

(22) **(d).** Use definition of relative velocity $\vec{V}_{PQ} = \vec{V}_P - \vec{V}_Q$

$$\vec{V}_P = \text{const.}; \vec{V}_Q = \text{const.}$$

$$\therefore |\vec{V}_{PQ}| = |\vec{V}_{QP}| = \text{const.} \; ; |\vec{V}_P| > |\vec{V}_Q|$$

$$\therefore \vec{V}_{PQ} \to +\text{ve}; \vec{V}_{QP} = -\text{ve} \text{ i.e. towards origin.}$$

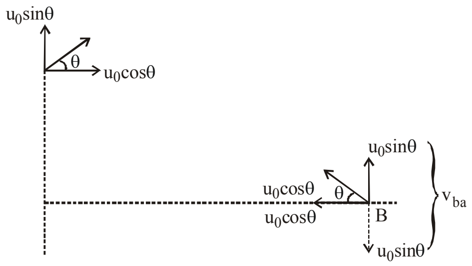
(23) **(c).** He can only reach the opposite point if he can cancel up the velocity of river by his component of velocity.

(24) **(a).** $v = R\omega$

$v_1 > v_2$

(25) (b), (26) (b), (27) (c).

The path of a projectile as observed by other projectile is a straight line.



$$v_A = u\cos\theta\,\hat{i} + (u\sin\theta - gt)\,\hat{j}. v_{AB} = (2u\cos\theta)\,\hat{i}$$

$$v_B = -u\cos\theta\,\hat{i} + (u\sin\theta - gt)\,\hat{j} \quad ; a_{BA} = g - g = 0$$

The vertical component $u_0 \sin\theta$ will get cancelled.

The relative velocity will only be horizontal which is equal to $2u_0 \cos\theta$

Hence B will travel horiozontally towards left w.r.t A with constant speed $2u_0 \cos\theta$ and minimum distance will be h.

$$\frac{S_{rel}}{V_{rel}} = \frac{\ell}{2u_0 \cos\theta}$$

(28) **(a)** When two bodies are moving in opposite direction, relative velocity between them is equal to sum of the velocity of bodies. But if the bodies are moving in same direction their relative velocity is equal to difference in velocity of the bodies.

(29) **(b)** Time taken is shortest when one aims perpendicular to the flow.

(30) **(d)** $v_{r/m} = \sqrt{v_r^2 + v_m^2}$