JEE MAIN ANSWER KEY & SOLUTIONS

SUBJECT :- PHYSICS
CLASS :- 11^{th} **PAPER CODE :- CWT-6**
CHAPTER :- CIRCULAR MOTION

ANSWER KEY

1.	(C)	**2.**	(A)	**3.**	(A)	**4.**	(D)	**5.**	(B)	**6.**	(A)	**7.**	(D)
8.	(B)	**9.**	(D)	**10.**	(B)	**11.**	(C)	**12.**	(D)	**13.**	(B)	**14.**	(C)
15.	(D)	**16.**	(C)	**17.**	(C)	**18.**	(B)	**19.**	(B)	**20.**	(C)	**21.**	2
22.	4	**23.**	1	**24.**	8	**25.**	1	**26.**	2π	**27.**	128	**28.**	4
29.	10	**30.**	20										

SOLUTIONS

1. (C)

Sol. $F_{C1} = F_{C2} \Rightarrow \frac{mv_1^2}{r_1} = \frac{mv_2^2}{r_2}$

$\frac{v_1}{v_2} = \sqrt{\frac{r_1}{r_2}} = \frac{1}{\sqrt{2}}$ **Ans.**

2. (A)

Sol. Uniformly rotating turn table means angular velocity is constant. New radius is half of the original value.

$r' = 2r$ and ω = constant

$v' = \omega r' = 2\omega r = 2v = 20$ cm/s

$a' = \omega^2 r' = 2\omega^2 r = 2a = 20$ cm/s^2

3. (A)

Sol. $mg = m\omega^2 R$, $\omega = \sqrt{\frac{g}{R}}$

4. (D)

Sol. $\omega_{QP} = 2\pi - 5\pi = -3\pi$ rad/s

$\omega_{RP} = 3\pi - 5\pi = -2\pi$ rad/s

Time when Q particle reaches at P $= t_1 = \frac{\pi/2}{3\pi}$

$= \frac{1}{6}$ sec.

$t_2 = \frac{5\pi/2}{3\pi} = \frac{5}{6}$ sec.

$t_3 = \frac{9\pi/2}{3\pi} = \frac{3}{2}$ sec.

Time where R particle reaches at P.

$t_1 = \frac{\pi}{2\pi} = \frac{1}{2}$ sec.

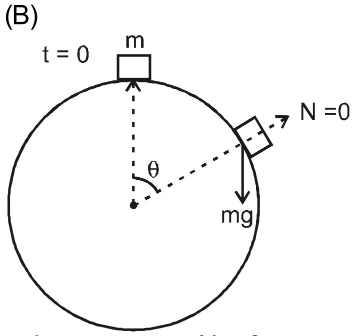
$t_2 = \frac{3\pi}{2\pi} = \frac{3}{2}$ sec.

Common time to reaches at P is

$\frac{3}{2}$ sec. **Ans.**

5. (B)

Sol.



at loose contact N = 0

$mg\cos\theta = \frac{mv^2}{R}$ ....(1)

from energy conservation

$mgR(1-\cos\theta) = \frac{1}{2}mv^2$ ....(2)

from (1) & (2)

$\cos\theta = \frac{2}{3} \Rightarrow \sin\theta = \frac{\sqrt{5}}{3}$

tangential acceleration $= g\sin\theta = \frac{\sqrt{5}\,g}{3}$ **Ans.**

6. (A)

Sol. Maximum tension in string at lowest

$T_{max} = \frac{mv_{LP}^2}{L} + mg$ ...(1)

maximum tension in string at heighest point.

$T_{min} = \frac{mv_{HP}^2}{L} - mg$ ...(2)

from energy conservation

$\frac{1}{2}mv_{LP}^2 = 2mgL + \frac{1}{2}mv_{HP}^2$ ....(3)

from (1) & (3)

$T_{max} = \frac{1}{L}mv_{HP}^2 + 5\,mg$ ...(4)

from (2) & (4)

$4 = \frac{T_{max}}{T_{min}} = \frac{\frac{mv_{HP}^2}{L}+5mg}{\frac{mv_{HP}^2}{L}-mg} \Rightarrow 3mv_{HP}^2 = 9\,mgL$

$\Rightarrow V_{HP} = \sqrt{3gL} = 10$ m/s **Ans.**

7. (D)

Sol. For vertical circular motion, in lower half circle tension never be zero anywhere. Tension is maximum at lowest point of oscillation. Tension decrease both side in same amount. Therefore correct option is (D).

8. (B)

Sol. $v = a\sqrt{s} \Rightarrow v^2 = a^2 s$

$a_t = v\dfrac{dv}{ds} = \dfrac{a^2}{2}$

$a_C = \dfrac{v^2}{R} = \dfrac{a^2 s}{R}$

$\tan\alpha = \dfrac{a_C}{a_t} = \dfrac{a^2 s/R}{a^2/2} = \dfrac{2s}{R}$ **Ans.**

9. (D)

Sol. Here, the constant horizontal force required to take the body from position 1 to position 2 can be calculated by using work-energy theorem. Let us assume that body is taken slowly so that its speed doesn't change, then

$\Delta K = 0$

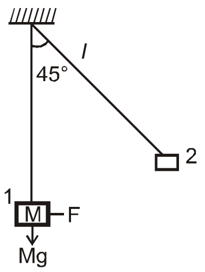
$= W_F + W_{Mg} + W_{tension}$

[symbols have their usual meanings]

$W_F = F \times \ell \sin 45°$,

$W_{Mg} = M_g(\ell - \ell\cos 45°)$, $W_{tension} = 0$

$\therefore \quad F = Mg(\sqrt{2} - 1)$



10. (B)

11. (C)

Sol. Since, speed is constant throughout the motion, so it is a uniform circular motion.

Therefore, its radial acceleration

$a = r\omega^2$

$= r\left(\dfrac{2\pi n}{t}\right)^2 = r \times \dfrac{4\pi^2 n^2}{t^2} = \dfrac{1 \times 4 \times \pi^2 \times (22)^2}{(44)^4}$

$= \pi^2$ m/s^2

This acceleration is directed along radius of circle.

12. (D)

Sol. Centripetal acceleration

$a_c = \omega^2 r = \left(\dfrac{2\pi}{T}\right)^2 r = \left(\dfrac{2\pi}{0.2\pi}\right)^2 \times 5 \times 10^{-2} = 5$ m/s^2

tangential acceleration is zero as constant speed so

acceleration $= \sqrt{a_c^{\,2} + a_t^{\,2}} = 5$ m/s^2

13. (B)

Sol. For banking $\tan\theta = \dfrac{V^2}{Rg}$

$\tan 45 = \dfrac{V^2}{90 \times 10} = 1 \qquad V = 30$ m/s

14. (C)

15. (D)

Sol. $\sqrt{6} = \sqrt{\left(\dfrac{v^2}{R}\right)^2 + (R\alpha)^2}$

(since $a_C = \dfrac{v^2}{R}$; $a_t = R\alpha$)

$\sqrt{6} = \sqrt{\dfrac{((R\alpha)^2)^2}{R^2} + R^2\alpha^2}$

$\because \quad v = (R\alpha).1$

$\therefore \quad \sqrt{6} = \sqrt{\dfrac{(\alpha R)^4}{R^2} + R^2\alpha^2}$

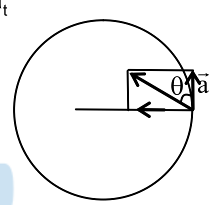
$\Rightarrow \quad 3\alpha^4 + 3\alpha^2 = 6$;

On solving $\alpha^2 = -2, 1$

So, the correct answer is 1 rad/s^2.

16. (C)

Sol. $\tan\theta = \dfrac{a_N}{a_t}$



17. (C)

Sol. $\tan\theta = \dfrac{1}{2}$, $g\cos\theta = a_t$

$10 \times \dfrac{20}{\sqrt{10^2 + 20^2}} = \dfrac{200}{\sqrt{100 + 400}} = \dfrac{20}{\sqrt{5}}$ m/s^2.

18. (B)

19. (B)

Sol. In time t particle has rotated an angle $\theta = \omega t$.

Displacement

$s = PQ = \sqrt{QR^2 + PR^2}$

$= \sqrt{(a\sin\omega t)^2 + (a - a\cos\omega t)^2}$

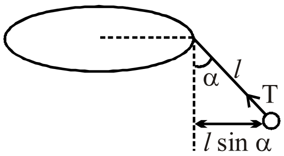
$s = 2a\sin\dfrac{\omega t}{2}$

20. (C)

Sol. We cannot choose (A) or (B) because the centripetal acceleration vector is not constant it continuously changes in direction. Of the remaining choices, only (C) gives the correct perpendicular relationship between ac and v.

21. 2

Sol. T cos a = mg



T sin a = $m\omega^2 r$

$\tan\alpha = \frac{\omega^2 r}{g}$

$\omega = \sqrt{\frac{g\tan\alpha}{r}} = \sqrt{\frac{10\times\frac{3}{4}}{\frac{35}{24}\times\frac{3}{5}+1}} = \sqrt{\frac{\frac{15}{2}}{\frac{15}{8}}} = 2$

rad/s

22. 4

Sol. $\tan\alpha = \frac{\omega^2 R}{R\alpha} = \frac{2\alpha\times 2\pi}{\alpha} = 4\pi$

23. 1

Sol. For just slip $\Rightarrow \mu mg = m\omega^2 r$

here ω is dLRouble then radius is $1/4^{th}$

r´ = 1 cm **Ans.**

24. 8

Sol. $T = \frac{mv^2}{r}$

$= \frac{0.5\times(4)^2}{1} = 8N$

25. 1

Sol. N = mg

$\mu N = m\, r\, \omega^2$

$\omega = \sqrt{\frac{\mu g}{2\sin\theta}}$

$\omega = \sqrt{\frac{0.1\times 10}{2\times\sin 30^\circ}}$

ω = 1 rad/s

26. 2π

Sol. $\vec{a} = \frac{\vec{v}_2-\vec{v}_1}{t_2-t_1} = \frac{-\pi\hat{i}-\pi\hat{j}}{1} = -2\pi\hat{i} = 2\pi\ m/s^2$

due west

$v = \frac{\pi R}{1} = \pi$ m/s]

27. 128

Sol. $\theta = \frac{14\times 10^8}{1.5\times 10^{11}} = \frac{14}{1.5}\times 10^{-3}$

$\omega = \frac{2\pi}{24\times 3600}$ $\quad t = \frac{\theta}{\omega}$

$t = \frac{14}{1.5}\times 10^{-3}\times\frac{24\times 3600}{2\pi}$

$t = \frac{14\times 8\times 3.6}{\pi} \simeq 128$ sec.

28. 4

Sol. $\tan\alpha = \frac{\omega^2 R}{R\alpha} = \frac{2\alpha\times 2\pi}{\alpha} = 4\pi$

29. 10

Sol. The lift goes down with retardation means acceleration is upward, let it be a.

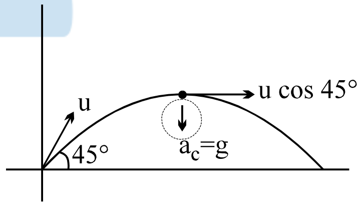
$T = 2\pi\sqrt{\frac{h}{g_{eff}}} = 2\pi\sqrt{\frac{h}{g+a}}$

$\Rightarrow\ 2 = 2\pi\sqrt{\frac{2}{10+a}} \Rightarrow a = 10$

30. 20

Sol. At highest point $a_c = g$

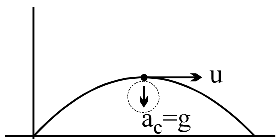
$\frac{u^2\cos^2 45^\circ}{R_c} = g$ [R_c = Radius of curvature]



$\frac{u^2}{2R_c} = g$ ....(1)

Now when be moves along the same path with constant speed u, then at top point, since radius of curvature (R_c) remains same

$\frac{u^2}{R_c} = a_c$ ....(2)



from (1) and (2)

$\frac{1}{2} = \frac{g}{a_c} \Rightarrow a_c = 2g$

$a_c = 20\ m/s^2$