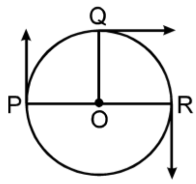
## Self Practice Paper (SPP)

**1.** Three point particles P, Q, R move in a circle of radius ' r ' with different but constant speeds. They start moving at t = 0 from their initial positions as shown in the figure. The angular velocities (in rad/sec) of P, Q and R are $5\pi$, $2\pi$ & $3\pi$ respectively, in the same sense. The time interval after which they all meet is:

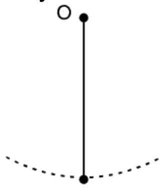


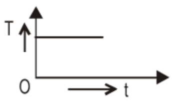

(1) 2/3 sec (2) 1/6 sec (3) 1/2 sec (4) 3/2 sec

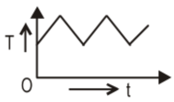
**2.** A stone of mass 1 kg tied to a light inextensible string of length L = $\frac{10}{3}$ m, whirling in a circular path in a vertical plane. The ratio of maximum tension in the string to the minimum tension in the string is 4, If g is taken to be 10 m/s$_2$, the speed of the stone at the highest point of the circle is :

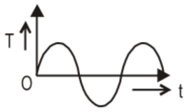
(1) 10 m/s (2) $5\sqrt{2}$ m/s (3) $10\sqrt{3}$ m/s (4) 20 m/s

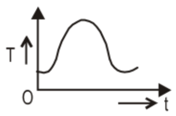
**3.** A particle of mass m is suspended from a fixed point O by a string of length $\ell$. It is displaced by angle $\theta$ ($\theta < 90°$) from equilibrium position and released from there at t = 0 . The graph, which shows the variation of the tension T in the string with time 't', may be :




(1) 


(2) 

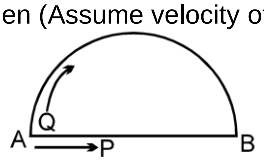

(3) 


(4) 


**4.** A particle moves along an arc of a circle of radius R. Its velocity depends on the distance covered s as $v = a\sqrt{s}$, where a is a constant then the angle $\alpha$ between the vector of the total acceleration and the vector of velocity as a function of s will be

(1) $\tan\alpha = \frac{R}{2s}$ (2) $\tan\alpha = 2s / R$ (3) $\tan\alpha = \frac{2R}{s}$ (4) $\tan\alpha = \frac{s}{2R}$

**5.** Two particles P and Q start their journey simultaneously from point A. P moves along a smooth horizontal circular wire with diameter AB. Q moves along a curved smooth track. Q has sufficient velocity at A to reach B always remaining in contact with the curved track. At A, the horizontal component of velocity of Q is same as the velocity of P along the wire. The plane of motion is vertical. If $t_1$, $t_2$, are times taken by P & Q respectively to reach B then (Assume velocity of P is constant)




(1) $t_1 = t_2$ (2) $t_1 > t_2$ (3) $t_1 < t_2$ (4) none of these

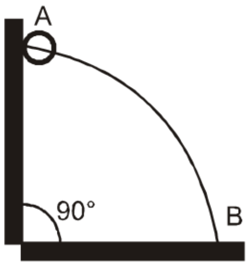
**6.** A particle is moving in a vertical circle. The tensions in the string when passing through two positions at angles 30° and 60° from vertical (lowest position) are $T_1$ and $T_2$ respectively. then

(1) $T_1 = T_2$ (2) $T_2 > T_1$
(3) $T_1 > T_2$ (4) Tension in the string always remains the same

**7.** A tube of length L is filled completely with an incompressible liquid of mass M and closed at both the ends. The tube is then rotated in a horizontal plane about one of its ends with a uniform angular velocity ω. The force exerted by the liquid at the other end is

(1) $\frac{ML\omega^2}{2}$ (2) $ML\omega^2$ (3) $\frac{ML\omega^2}{4}$ (4) $\frac{ML^2\omega^2}{2}$

**8.** A wire, which passes through the hole is a small bead, is bent in the form of quarter of a circle. The wire is fixed vertically on ground as shown in the figure. The bead is released from near the top of the wire and it slides along the wire without friction. As the bead moves from A to B, the force it applies on the wire is




(1) always radially outwards
(2) always radially inwards
(3) radially outwards initially and radially inwards later
(4) radially inwards initially and radially outwards later.

## SPP Answers

**1.** (4) **2.** (1) **3.** (4) **4.** (2) **5.** (2) **6.** (3) **7.** (1)
**8.** (4)

## SPP Solutions

**1.** $\omega_{QP} = 2\pi - 5\pi = -3\pi$ 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.**

**2.** Maximum tension in string at lowest

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

maximum tension in string at highest point.

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

from energy conservation

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

from (1) & (3)

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

from (2) & (4)

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

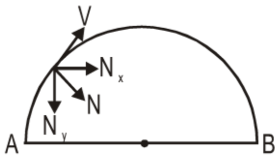
$\Rightarrow$ $V_{HP} = \sqrt{3gL} = 10$ m/s **Ans.**

**3.** 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 (4).

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

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

$a_c = \frac{v^2}{R} = \frac{a^2 s}{R}$ $\Rightarrow$ $\tan\alpha = \frac{a_c}{a_t} = \frac{a^2 s/R}{a^2/2} = \frac{2s}{R}$ **Ans.**

**5.** 


The horizontal component of velocity of Q will increase and become maximum at the top ; and will again become same at B. Because of its greater horizontal velocity the particle Q will reach B earlier than P

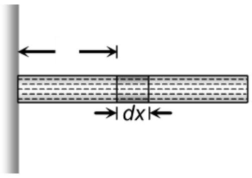
$\therefore \quad t_1 > t_2$ .

**6.** Tension, $T = \frac{mv^2}{r} + mg\cos\theta$

For, $\theta = 30°, T_1 = \frac{mv^2}{r} + mg\cos 30°$

$\theta = 60°, T_2 = \frac{mv^2}{r} + mg\cos 60° \therefore T_1 > T_2$

**7.** $dM = \left(\frac{M}{L}\right)dx$




force on 'dM' mass is

$dF = (dM)\omega^2 x$

By integration we can get the force exerted by whole liquid

$\Rightarrow \quad F = \int_0^L \frac{M}{L}\omega^2 x\,dx = \frac{1}{2}M\omega^2 L$

**8.** Using conservation of energy : mgR (1- cosθ) = $\frac{1}{2}$ $mv^2$

Radial force Equ$_n$ : mgcosθ – N = $\frac{mv^2}{R}$

$\Rightarrow$ N = mgcosθ – $\frac{mv^2}{R}$ = mg (3 cosθ–2)

Normal act radially outward on bead if cosθ > $\frac{2}{3}$

Normal radially inward on bead if cos θ < $\frac{2}{3}$

$\therefore$ Normal on ring is opposite to reaction on bead.