**PHYSICS**

# DPP

DAILY PRACTICE PROBLEMS

# DPP No. 49

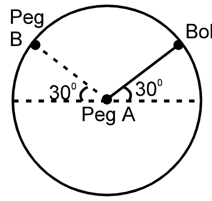
**Total Marks : 30**

**Max. Time : 31 min.**

**Topics : Circular Motion, Work, Power and Energy, Center of Mass**

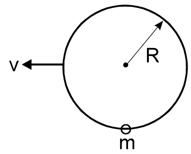
| Type of Questions | | M.M., Min. |
|---|---|---|
| Single choice Objective ('–1' negative marking) Q.1 to Q.3 | (3 marks, 3 min.) | [9, 9] |
| Multiple choice objective ('–1' negative marking) Q.4 to Q.5 | (4 marks, 4 min.) | [8, 8] |
| Subjective Questions ('–1' negative marking) Q.6 | (4 marks, 5 min.) | [4, 5] |
| Comprehension ('–1' negative marking) Q.7 to Q.9 | (3 marks, 3 min.) | [9, 9] |

**1.** A bob is attached to one end of a string other end of which is fixed at peg A. The bob is taken to a position where string makes an angle of $30^0$ with the horizontal. On the circular path of the bob in vertical plane there is a peg 'B' at a symmetrical position with respect to the position of release as shown in the figure. If $V_c$ and $V_a$ be the minimum speeds in clockwise and anticlockwise directions respectively, given to the bob in order to hit the peg 'B' then ratio $V_c : V_a$ is equal to :




(A) 1 : 1 (B) $1 : \sqrt{2}$ (C) 1 : 2 (D) 1 : 4

**2.** A ring of radius R lies in vertical plane. A bead of mass 'm' can move along the ring without friction. Initially the bead is at rest at the bottom most point on ring. The minimum horizontal speed v with which the ring must be pulled such that the bead completes the vertical circle

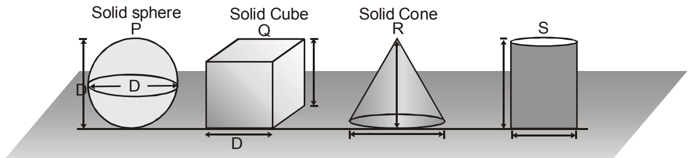



(A) $\sqrt{3gR}$ (B) $\sqrt{4gR}$ (C) $\sqrt{5gR}$ (D) $\sqrt{5.5gR}$

**3.** An object is moving in a circle at constant speed v. The magnitude of rate of change of momentum of the object

(A) is zero (B) is proportional to v (C) is proportional to $v^2$ (D) is proportional to $v^3$

**4.** Assuming potential energy 'U' at ground level to be zero.



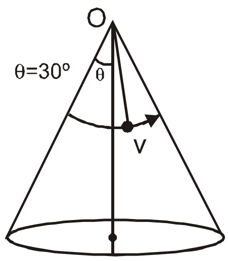

All objects are made up of same material.

$U_P$ = Potential energy of solid sphere  $U_Q$ = Potential energy of solid cube

$U_R$ = Potential energy of solid cone  $U_S$ = Potential energy of solid cylinder

(A) $U_S > U_P$ (B) $U_Q > U_S$ (C) $U_P > U_Q$ (D) $U_P > U_S$

**5.** A bob of mass 2 kg is suspended from point O of a cone with an inextensible string of length $\sqrt{3}$ m. It is moving in horizontal circle over the surface of cone as shown in the figure. Then : (g = 10 m/s²)



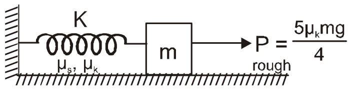

(A) bob looses contact with cone if $v > \sqrt{5}$ m/s

(B) normal force on bob is 19 N when v = 2 m/s

(C) tension in string is $\frac{38}{\sqrt{3}}$ N when v = 2 m/s

(D) normal force on bob is $\frac{17}{\sqrt{3}}$ N when v = 2m/s

**6.** A block of mass m rests on a rough horizontal plane having coefficient of kinetic friction $\mu_k$ and coefficient of static friction $\mu_s$. The spring is in its natural length, when a constant force of magnitude $P = \frac{5\mu_k mg}{4}$ starts acting on the block. The spring force F is a function of extension x as $F = kx^3$. (Where k is spring constant)

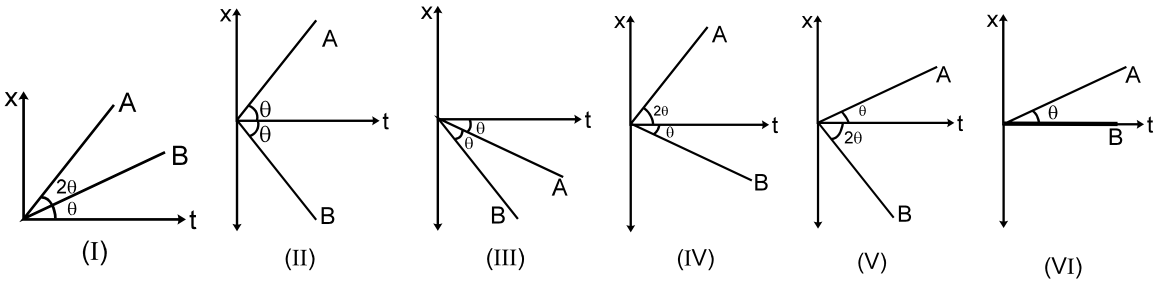



(a) Comment on the relation between $\mu_s$ and $\mu_k$ for the motion to start.

(b) Find the maximum extension in the spring (Assume the force P is sufficient to make the block move).

**COMPREHENSION**

An initially stationary box on a frictionless floor explodes into two pieces, piece A with mass $m_A$ and piece B with mass $m_B$. Two pieces then move across the floor along x-axis. Graph of position versus time for the two pieces are given.




**7.** Which graphs pertain to physically possible explosions ?

(A) II, V (B) VI (C) I, III (D) IV

**8.** Based on the above question, Match column A with the column B.

| **Column A** | **Column B (Graph number)** |
|---|---|
| (P) $m_A = m_B$ | I |
| (Q) $m_A > m_B$ | II |
| (R) $m_A < m_B$ | III |
| | IV |
| | V |
| | VI |

(A P-VI, Q-III, R -I (B) P-II, Q-V, R-IV (C) P-II, Q-IV, R-V (D) P-VI, Q-II, R-IV

**9.** If all the graphs are possible then, in which of the following cases external force must be acting on the box

(A) II (B) V (C) VI (D) I

# Answers Key

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**1.** (C) **2.** (B) **3.** (C)
**4.** (A), (B) **5.** (A), (C)

**6.** (a) $5\mu_k > 4\mu_s$ , (b) $x = \left(\frac{\mu_K mg}{K}\right)^{1/3}$

**7.** (A), (D) **8.** (B) **9.** (C), (D)

# Hint & Solutions

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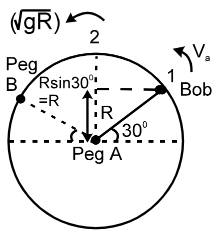
**1.** (C) For anti-clockwise motion, speed at the highest point should be $\sqrt{gR}$ . Conserving energy at (1) & (2) :




$$\frac{1}{2}mv_a^2 = mg\frac{R}{2} + \frac{1}{2}m(gR)$$

$\Rightarrow$ $v_a^2 = gR + gR = 2gR$

$\Rightarrow$ $v_a = \sqrt{2gR}$

For clock-wise motion, the bob must have atleast that much speed initially, so that the string must not become loose any where until it reaches the peg B.

At the initial position :

$T + mg\cos 60^0 = \frac{mv_c^2}{R}$ ; $V_c$ being the initial speed in clockwise direction.

For $V_{C\,min}$ : Put T = 0 ;

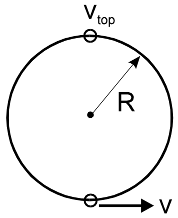
$V_{C\,min}$ : T = 0

$$\Rightarrow V_C = \sqrt{\frac{gR}{2}}$$

$$\Rightarrow V_C/V_a = \frac{\sqrt{\frac{gR}{2}}}{\sqrt{2gR}} = \frac{1}{2}$$

$\Rightarrow V_C : V_a = 1 : 2$ **Ans.**

**2.** In the frame of ring (inertial w.r.t. earth), the initial velocity of the bead is v at the lowest position.




The condition for bead to complete the vertical circle is, its speed at top position

$v_{top} \geq 0$

From conservation of energy

$$\frac{1}{2}m\,v_{top}^2 + mg\,(2R) = \frac{1}{2}mv^2$$

or $v = \sqrt{4gR}$

**3.** As the speed is constant, so there is only $a_n \propto v^2$.

Hence the net force is equal to $\frac{mv^2}{R}$. Hence the magnitude of rate of change of momentum (i.e. force) is proportional to $v^2$.

**5.** T cos30º + N sin30º = mg

$\Rightarrow \sqrt{3}\,T + N = 2\,mg$ ..............(i)

$T\sin30^\circ - N\cos30^\circ = \frac{mv^2}{(\sqrt{3}/2)}$ $\Rightarrow$ T

sin30º – 3N = 4mv²

$\sqrt{3}T - 3N = 4mv^2$ ..............(ii) by (i),)(ii) $\Rightarrow$ $N = \dfrac{2mg - 4mv^2}{4}$ ; $T = \dfrac{6mg - 4mv^2}{4\sqrt{3}}$

for N > 0 $\Rightarrow$ $v < \sqrt{5}$ m/s

at v = 2 $T = \dfrac{38}{\sqrt{3}}$ N ; N = 2N.

**Solution :**

In P, Q and S; the centre of masses lie at D/2 height from the base level. Where as in R(cons) the com lies at D/4 height from the base.

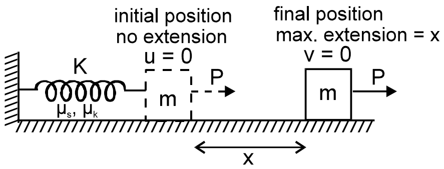
Hence $U_P > U_Q$.

Ans. (C).

**6.** (a) For motion to start

$$\frac{5\mu_k mg}{4} > \mu_s mg \quad \text{or} \quad 5\mu_k > 4\mu_s$$

(b)




At the final position of the block extension in spring is maximum and the speed of the block is v = 0. Hence the net work done in taking the block from initial to final position

$\Delta W$ = work done by P + work done by spring force F + work done by friction = 0

$$= P\,x - \int_0^x Kx^3 \,.\, dx - \mu mgx = \frac{5\mu_k mg}{4}\,x - \frac{Kx^4}{4}$$

$- \mu_k mgx = 0$

solving we get $x = \left(\dfrac{\mu_K mg}{K}\right)^{1/3}$ **Ans.**