PHYSICS

DPP

DAILY PRACTICE PROBLEMS

DPP No. 57

Total Marks : 24

Max. Time : 25 min.

Topics : Rigid Body Dynamics, Newton's Law of Motion, Circular Motion, Center of Mass

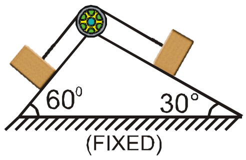
Type of Questions		M.M., Min.
Single choice Objective ('–1' negative marking) Q.1 to Q.4	(3 marks 3 min.)	[12, 12]
Multiple choice objective ('–1' negative marking) Q.5 to Q.6	(4 marks 4 min.)	[8, 8]
Subjective Questions ('–1' negative marking) Q.7	(4 marks 5 min.)	[4, 5]

1. The moment of inertia of a door of mass m, length 2ℓ and width ℓ about its longer side is

(A) $\frac{11m\ell^2}{24}$ (B) $\frac{5m\ell^2}{24}$

(C) $\frac{m\ell^2}{3}$ (D) none of these

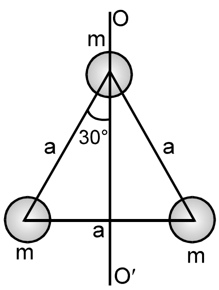
2. Two blocks of equal mass are ties with a light string which passes over a massless pulley as shown in figure. The magnitude of acceleration of centre of mass of both the blocks is (neglect friction everywhere):



(A) $\frac{\sqrt{3}-1}{4\sqrt{2}}g$ (B) $(\sqrt{3}-1)g$

(C) $\frac{g}{2}$ (D) $\left(\frac{\sqrt{3}-1}{\sqrt{2}}\right)g$

3. Three point masses are arranged as shown in the figure. Moment of inertia of the system about the axis O O′ is : (passing through its plane)



(A) $2\,m\,a^2$ (B) $\frac{ma^2}{2}$

(C) $m\,a^2$ (D) none of these

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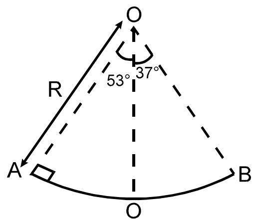
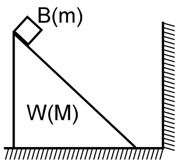
4. A section of fixed smooth circular track of radius R in vertical plane is shown in the figure. A block is released from position A and leaves the track at B. The radius of curvature of its trajectory when it just leaves the track at B is:



(A) R (B) $\frac{R}{4}$ (C) $\frac{R}{2}$ (D) none of these

5. In the figure, the block B of mass m starts from rest at the top of a wedge W of mass M. All surfaces are without friction. W can slide on the ground. B slides down onto the ground, moves along ground with a speed υ' has an elastic collision with the wall, and climbs back onto W.



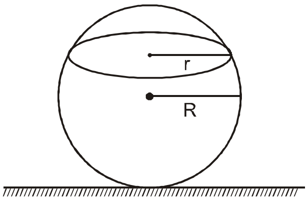
(A) B will reach the top of W again
(B) from the beginning, till the collision with the wall, the centre of mass of 'B + W' is stationary in horizontal direction
(C) after the collision the centre of mass of 'B + W' moves with the velocity $\frac{2m\upsilon}{m+M}$
(D) when B reaches its highest position on W, the speed of W is $\frac{2m\upsilon}{m+M}$

6. In a free space a rifle of mass M shoots a bullet of mass m at a stationary block of mass M distance D away from it. When the bullet has moved through a distance d towards the block the centre of mass of the bullet-block system is at a distance of :

(A) $\frac{(D-d)\,m}{M+m}$ from the block (B) $\frac{md+MD}{M+m}$ from the rifle

(C) $\frac{2\,dm+DM}{M+m}$ from the rifle (D) $(D-d)\frac{M}{M+m}$ from the bullet

7. A uniform circular chain of radius r and mass m rests over a sphere of radius R as shown in figure. Friction is absent everywhere and system is in equilibrium. Find the tension in the chain.



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Answers Key

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

5. (B), (C), (D) **6.** (A), (D)

7. $T = \frac{mg}{2\pi}\frac{r}{\sqrt{R^2 - r^2}}$

Hint & Solutions

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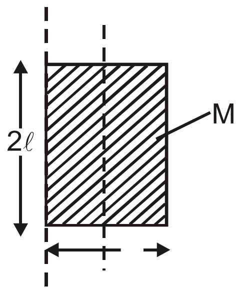
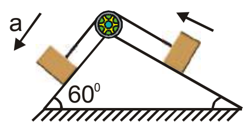
1. 

$I_2 = \frac{m\ell^2}{3}$.

2. Accelerates of blocks



$$a = \frac{mg(\sin 60° - \sin 30°)}{m + m}$$

$$= \frac{g}{2}\left(\frac{\sqrt{3}}{2} - \frac{1}{2}\right) \quad = \frac{g}{4}\sqrt{3} - 1$$

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$$\vec{a}_{cm} = \frac{m[a\cos 60°(-\hat{i}) - a\sin 60°\,\hat{j}] + ma\sin 60°(-\hat{i}) + m(a\cos 60°)\hat{j}}{m+m}$$

$$= \frac{ma}{2m}\left[\left[\frac{-1}{2} - \frac{\sqrt{3}}{2}\right]\hat{i} + \left(\frac{1}{2} - \frac{\sqrt{3}}{2}\right)\hat{j}\right] \quad =$$

$$\frac{a}{4}\left[-(1+\sqrt{3})\,\hat{i} + (1-\sqrt{3})\,\hat{j}\right]$$

$$a_{cm} = \frac{a}{4}\sqrt{\left[(1+\sqrt{3})\,\hat{i} + (1-\sqrt{3})\,\hat{j}\right]} \quad =$$

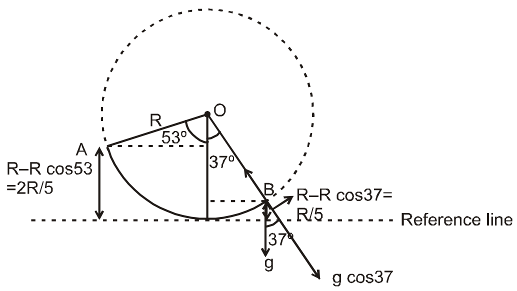
$$\frac{a}{4}\sqrt{1+3+2\sqrt{3}+1-2\sqrt{3}+3} \quad = \frac{a}{4}\sqrt{8}$$

$$= \frac{a}{4}2\sqrt{2} \quad = \frac{a}{\sqrt{2}} \quad a_{cm} = \frac{g}{4\sqrt{2}}(\sqrt{3}-1).$$

3. $0 + \frac{ma^2}{4} + \frac{ma^2}{4} = \frac{ma^2}{2}$

4. By energy conservation between A & B

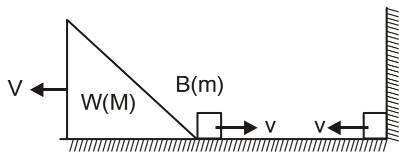
$$\Rightarrow Mg\frac{2R}{5} + 0 = \frac{MgR}{5} + \frac{1}{2}MV^2$$



$$V = \sqrt{\frac{2gR}{5}}$$

Now, radius of curvature r

$$= \frac{V_{\perp}^2}{a_r} = \frac{2gR/5}{g\cos 37} = \frac{R}{2}$$

5. 

From linear conservation

mv = MV

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$V = \frac{mV}{M}$

After the elastic collision with wall speed of the block B remain same in the direction V

$$V_{cm} = \frac{m(v) + M\left(\frac{mv}{M}\right)}{m + M}$$

$$= \frac{2mV}{m + M}$$

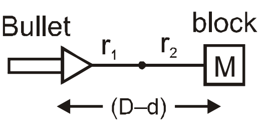
When block B will reach at maximum height on wedge

From momentum conservation

$$\frac{mv}{M}.M + mv = (m + M)\,V_C$$

$$V_C = \frac{2mv}{(M+m)}.$$

6.



centre of mass is localed at distance r_2 from block

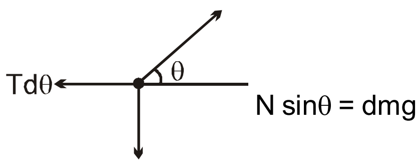
$Mr_2 = mr_1 \quad Mr_2 = m\,(D - d - r_2)$

$$r_2 = \frac{m(D-d)}{M+m}$$

also $M\,(D - d - r_1) = mr_1$

so $r_1 = \frac{M(D-d)}{(M+m)}$ distance of COM from bullet.

7. Consider the dm mass of chain subtending angle at $d\alpha$ centre



$N\cos\theta = T\,d\alpha$

$$\tan\theta = \frac{dm}{d\alpha}.\frac{g}{T}$$

$$\tan\theta = \frac{m}{2\pi}.\frac{g}{T}\ ;\ \tan\theta = \frac{\sqrt{R^2 - r^2}}{r} = \frac{m}{2\pi}\ \frac{g}{T}$$

$$T = \frac{mg}{2\pi}\frac{r}{\sqrt{R^2 - r^2}}$$ **Ans.**

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