PHYSICS

DPP

DAILY PRACTICE PROBLEMS

DPP No. 60

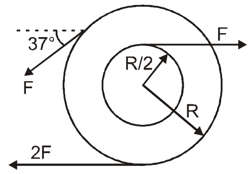
Total Marks : 28

Max. Time : 30 min.

Topics : Rigid Body Dynamics, Work ,Power and Energy, Center of Mass, Friction

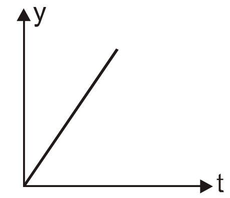
Type of Questions		M.M., Min.
Single choice Objective ('–1' negative marking) Q.1	(3 marks, 3 min.)	[3, 3]
Multiple choice objective ('–1' negative marking) Q.2 to Q.3	(4 marks, 4 min.)	[8, 8]
Subjective Questions ('–1' negative marking) Q.4 to Q. 5	(4 marks, 5 min.)	[8, 10]
Comprehension ('–1' negative marking) Q.6 to Q.8	(3 marks, 3 min.)	[9, 9]

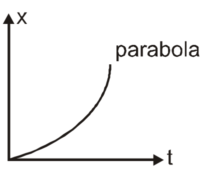
1. On a disc of radius R a concentric circle of radius R/2 is drawn.The disc is free to rotate about a frictionless fixed axis through its center and perpendicular to plane of the disc. All three forces (in plane of the disc) shown in figure are exerted tangent to their respective circular periphery. The magnitude of the net torque (about centre of disc) acting on the disc is:

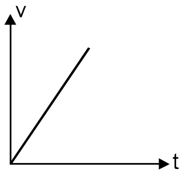


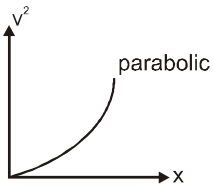
(A) 1.5 FR (B) 1.9 FR (C) 2.3 FR (D) 2.5 FR

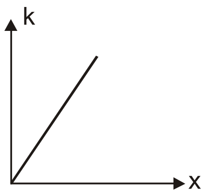
2. A particle starts moving from rest from the origin & moves along positive x-direction. Its rate of change of kinetic energy with time shown on y-axis varies with time t as shown in the graph. If position, velocity, acceleration & kinetic energy of the particle at any time t are x, v, a & k respectively then which of the option (s) may be correct ?



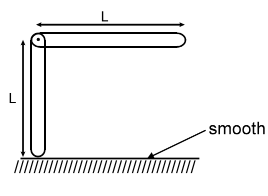
(A)


(B)


(C)


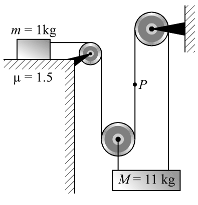
(D)


3. Two identical rods are joined at one of their ends by a pin. Joint is smooth and rods are free to rotate about the joint. Rods are released in vertical plane on a smooth surface as shown in the figure. The displacement of the joint from its initial position to the final position is (i.e. when the rods lie straight on the ground)



(A) $\frac{L}{4}$ (B) $\frac{\sqrt{17}}{4}$ L (C) $\frac{\sqrt{5}L}{2}$ (D) none of these

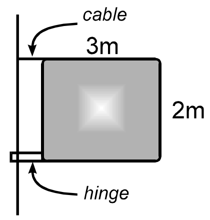
4. Figure shows an ideal pulley block of mass *m* = 1 kg, resting on a rough ground with friction coefficient μ = 1.5. Another block of mass *M* = 11 kg is hanging as shown. When system is released it is found that the magnitude of acceleration of point P on string is a. Find value of 4a in m/s^2.
(Use g = 10 m/s^2)



5. In figure the uniform gate weighs 300 N and is 3 m wide & 2 m high. It is supported by a hinge at the bottom left corner and a horizontal
cable at the top left corner, as shown. Find :

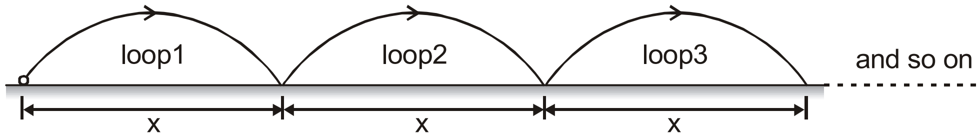
(a) the tension in the cable and

(b) the force that the hinge exerts on the gate (magnitude & direction).

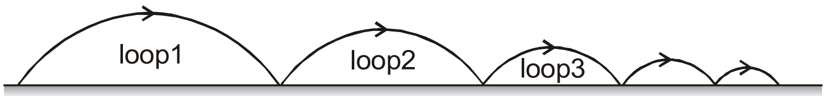


COMPREHENSION

A ball is projected on a very long floor. There may be two conditions
(i) floor is smooth & (ii) the collision is elastic
If both are considered then the path of ball is as follows.



Now if collision is inelastic and surface is rough then the path is as follows.



Successive range is decreasing.
Roughness of surface decreases the horizontal component of ball during collision and inelastic nature of collision decreases the vertical component of velocity of ball. In first case both components remain unchanged in magnitude and in second case both the components of the velocity will change.
Let us consider a third case here surface is rough but the collision of ball with floor is elastic. A ball is projected with speed u at an angle 30° with horizontal and it is known that after collision with the floor its speed becomes $\frac{u}{\sqrt{3}}$. Then answer the following questions.

6. The angle made by the resultant velocity vector of the ball with horizontal after first collision with floor is :
(A) 30° (B) 60° (C) 90° (D) 45°

7. The ratio of maximum height reached by ball in first loop and second loop $\left(\frac{H_1}{H_2}\right)$ is :

(A) $\frac{1}{4}$ (B) $\frac{1}{2}$ (C) 1 (D) $\frac{1}{\sqrt{3}}$

8. If the ball after first collision with the floor had rebounded vertically then the speed of the ball just after the collision with the floor would have been :

(A) u (B) u/2 (C) $\frac{\sqrt{3}}{2}$u (D) None of these

Answers Key

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1. (A) **2.** (A,B,D) **3.** (B,D) **4.** 13
5. (a) T = 225N, (b) F_X = 225N, F_Y = 300N
6. (B) **7.** (C) **8.** (B)

Hint & Solutions

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1. Torque $\tau = (2F)R + F\left(\frac{R}{2}\right) + FR(-1)$

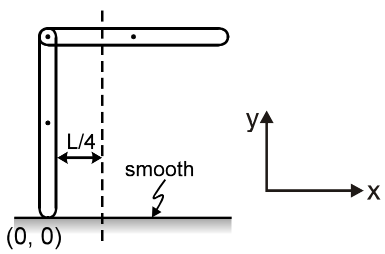
$= \frac{3FR}{2}$

2. $\frac{dk}{dt} \propto t$

$\Rightarrow k \propto t^2$ ....(i)
$\Rightarrow v \propto t$ ....(ii)
$\Rightarrow$ v vs t : st. line
$\Rightarrow x \propto t^2$ ....(iii)
$\Rightarrow$ x vs t : parabola
(i) & (iii)
$\Rightarrow k \propto x$ ....(iv)
$\Rightarrow$ k vs x : st. line
(ii) $\Rightarrow$ a = constant
(ii) & (iii) $\Rightarrow v^2 \propto x$..............(v) v^2 vs x : st. line

3. Initially the centre of mass is at $\frac{L}{4}$ distance from the vertical rod.

$\left(\text{As, } x_{cm} = \frac{m(\frac{1}{2}) + m(0)}{m+m} = \frac{L}{4}\right)$



centre of mass does not move in x-direction as $\Sigma F_x = 0$.

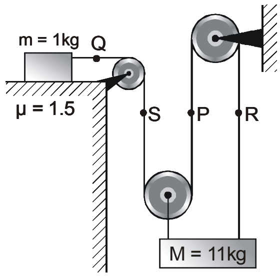
After they lie on the floor, the pin joint should be at L/4 distance from the origin shown inorder to keep the centre of mass at rest.

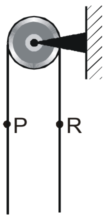
$\therefore$ Finally x-displacement of the pin is $\frac{L}{4}$ and y-displacement of the pin is obviously L.

Hence net displacement = $\sqrt{L^2 + \frac{L^2}{16}} = \frac{\sqrt{17}L}{4}$

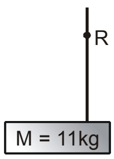
4. Ans. [13]

Sol.

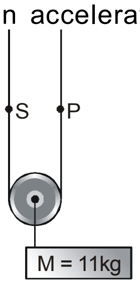




If the point P has an acceleration a upwards then the acceleration of point R will be a downwards.



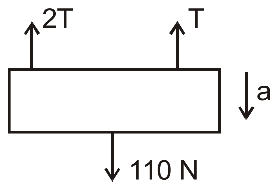
The point R has an acceleration a downwards so the block will also have an acceleration a downwards.



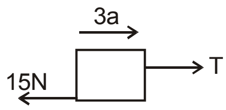
The point P has an acceleration a upwards, the block has an acceleration a downwards so the acceleration of S will be 3a downwards. (because $\frac{\vec{a}_S + \vec{a}_P}{2} = \vec{a}_{block}$).

The point Q will also have an acceleration 3a towards right.

The F.B.D. of 11kg block



The F.B.D. of 1kg block



Using FBD of 11 kg block, which will have acceleration a downwards.

110 – 3T = 11a .... (1) (in downwards direction)

For 1 kg block, which will have acceleration 3a,

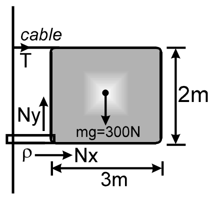
T – 15 = 3a (in horizontal direction)

or 3T – 45 = 9a .... (2)

on adding equation (1) & (2) we get

20a = 65 $\Rightarrow$ 4a = 13 m/s^2

5.



From FBD

Equation in horizontal direction

T = Nx ....(1)

For Rotational equation about P

T. 2 = 1.5 × 300

T = 225 N

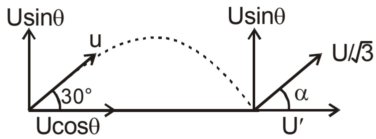
N_x = 225 N

N_y = 300 N

And Ng = mg = 300 N

6.to 8 As the collision is elastic vertical component remains unchanged but the rough floor changes the horizontal component.

$$\therefore\ U'^2 = \left(\frac{U}{\sqrt{3}}\right)^2 - (U \sin 30°)^2 \quad \therefore\ U' = \frac{U}{2\sqrt{3}}$$



$$\text{Now } \tan\alpha = \left(\frac{U'}{U\sin\theta}\right)^{-1} = \sqrt{3} \quad \therefore\ \alpha = 60°.$$

7. As the vertical components remain unchanged therefore the vertical height achieved will remain same.

$$\therefore\ \frac{H_1}{H_2} = 1$$

8. If it rebounded vertically then U′ would have been zero and vertical component velocity would only remain which is equal to $u \sin\theta = u \sin 30° = \frac{u}{2}$.