PHYSICS

DPP

DAILY PRACTICE PROBLEMS

DPP No. 64

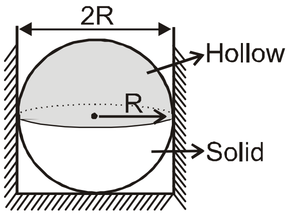
Total Marks : 27

Max. Time : 29 min.

Topics : Center of Mass, Newton's law of Motion, Relative Motion, Rigid Body Dynamics, Friction

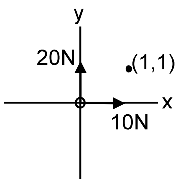
Type of Questions		M.M., Min.
Single choice Objective ('–1' negative marking) Q.1 to Q.2	(3 marks, 3 min.)	[6, 6]
Multiple choice objective ('–1' negative marking) Q.3	(4 marks, 4 min.)	[4, 4]
Subjective Questions ('–1' negative marking) Q.4 to Q.5	(4 marks, 5 min.)	[8, 10]
Comprehension ('–1' negative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

1. A compound sphere is made by joining a hemispherical shell and a solid hemisphere of same radius R and same mass as shown in figure. This system is kept between two smooth parallel walls and a smooth floor with the hollow hemisphere on the top as shown in figure. The maximum angular velocity of the compound sphere when the system is slightly disturbed is (all surfaces are smooth)



(A) $\sqrt{\frac{15g}{64R}}$ (B) $\sqrt{\frac{15g}{32R}}$ (C) $\sqrt{\frac{15g}{16R}}$ (D) $\sqrt{\frac{15g}{8R}}$

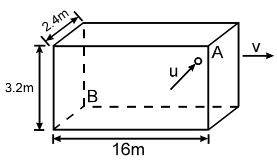
2. A particle is placed at the origin of the coordinate system. Two forces of magnitude 20 N & 10 N act on it as shown in figure. It is found that it starts moving towards the point (1,1). The net unknown force acting on the particle at this position can be :



(A) $15\sqrt{2}$ at angle 45° with positive x axis (B) $5\sqrt{2}$ at angle 135° with positive x axis

(C) $5\sqrt{2}$ at angle -45° with positive x axis (D) None of these

3. A railway compartment is 16 m long, 2.4 m wide and 3.2 m high. It is moving with a velocity V. A particle moving horizontally with a speed u, perpendicular to the direction of V, enters through a hole at an upper corner A and strikes the diagonally opposite corner B. Assume g = 10 m/s^2.



(A) υ = 20 m/s
(B) u = 3 m/s
(C) to an observer inside the compartment, the path of the particle is a parabola
(D) to a stationary observer outside the compartment, the path of the particle is a parabola

4. In the figure (i) a disc of mass M (kg) and radius R (m) is rotating smoothly about a fixed vertical axis AB with angular speed 26 rad/s. A rod CD of length $\frac{R}{2}$ (m) and mass M (kg) is hinged at one end at point 'D' on the disc. The rod remains in vertical position and rotates along with the disc about axis AB. At some moment the rod CD gets a very small impulse at point 'C' due to air due to which the rod falls on the disc along one radius and sticks to the disc as shown in figure (ii). Now find the angular velocity of the disc in rad/s.

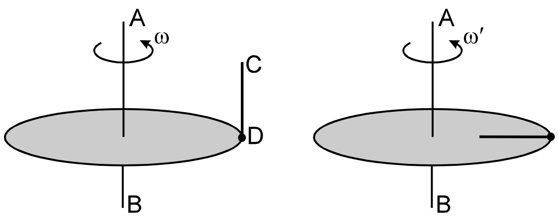
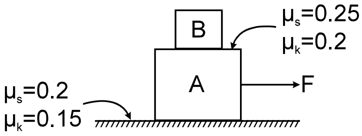


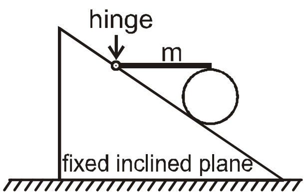
Figure (i) Figure (ii)

5. Block B of mass 2 kg rests on block A of mass 10 kg. All surfaces are rough with the value of coefficient of friction as shown in the figure. Find the minimum force F that should be applied on block A to cause relative motion between A and B. (g = 10 m/s^2)



COMPREHENSION

A horizontal uniform rod of mass 'm' has its left end hinged to the fixed incline plane, while its right end rests on the top of a uniform cylinder of mass 'm' which in turn is at rest on the fixed inclined plane as shown. The coefficient of friction between the cylinder and rod, and between the cylinder and inclined plane, is sufficient to keep the cylinder at rest.



6. The magnitude of normal reaction exerted by the rod on the cylinder is

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

7. The ratio of magnitude of frictional force on the cylinder due to the rod and the magnitude of frictional force on the cylinder due to the inclined plane is:

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

8. The magnitude of normal reaction exerted by the inclined plane on the cylinder is:

(A) mg (B) $\frac{3mg}{2}$ (C) 2mg (D) $\frac{5mg}{4}$

Answers Key

DPP NO. - 64

1. (B) **2.** (C) **3.** (A) (B) (C) (D)
4. 36 **5.** 48 N **6.** (C) **7.** (A) **8.** (B)

Hint & Solutions

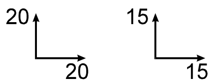
DPP NO. - 64

1. Change in PE = Increase in K.E.

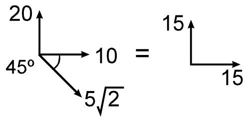
$$Mg\left[\frac{R}{2}2-\frac{3R}{8}2\right] = \frac{1}{2}\left[\frac{2}{5}MR^2+\frac{2}{3}MR^2\right]\omega^2 \qquad \frac{g}{4}$$

$$= \frac{2}{2}\left[\frac{1}{5}+\frac{1}{3}\right]R\omega^2 \qquad \sqrt{\frac{15g}{32R}} = \omega$$

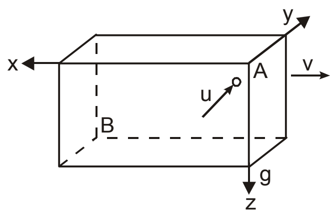
2. Check the options so that the resultant force comes towards (1, 1). i.e. $F_{xnet} = F_{ynet}$
(There exist infinite solutions because the acceleration is not given, for example



etc.)



3. Time of flight



$$\Rightarrow t = \sqrt{\frac{2h}{g}} = \sqrt{\frac{2\times3.2}{10}} = 0.8 \text{ sec.}$$

$y = V_y t$
$\Rightarrow$ 2.4 = U× 0.8 U = 3 m/s
$x = V_x t$
$\Rightarrow$ 16 = V × 0.8 V = 20 m/s

Angle between $\vec{a}$ & $\vec{v}$ is other then 0° or 180°,

4. MI of the system when rod is vertical

$$I = \frac{1}{2} m R^2 + m R^2$$

MI of system when rod is horizontal

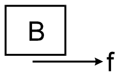
$$I' = \frac{1}{2} m R^2 + \left[\frac{m\left(\frac{R}{2}\right)^2}{12} + m\left(\frac{3R}{4}\right)^2 \right]$$

$$= \frac{13}{12} m R^2$$

from conservation of angular momentum of system about axis AB is

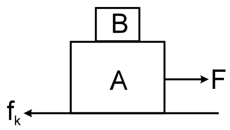
$$I\omega = I' \omega'$$

$$\text{or} \quad \omega' = \frac{\frac{3}{2} mR^2 \omega}{\frac{13}{12} mR^2} = \frac{18}{13} \omega$$

5. FBD of B 

$$(a_B)_{max} = \frac{f_{max}}{m_B} = \mu_S g = 2.5 \text{ m/s}^2$$

FBD of combined system



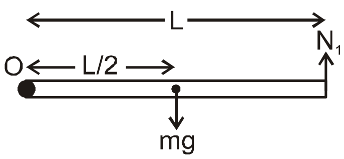
$f_k = 0.15\ (2 + 10)\ g = 18$ N

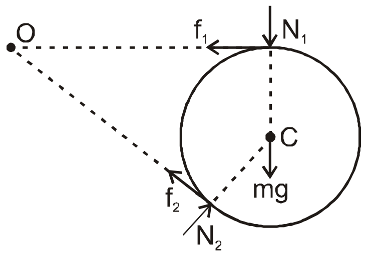
$F_{max} - f_k = (m_A + m_B)\ (a_B)_{max}$

$\Rightarrow \quad F_{max} = f_k + 12 \times 2.5 = 48$ N.**Ans. 48 N.**

Sol. 6 to 8.

FBD of rod and cylinder is as shown.





Net torque on rod about hinge 'O' = 0

$\therefore N_1 \times L = mg \times \frac{L}{2}$ or $\boxed{N_1 = \frac{mg}{2}}$

Net torque on cylinder about its centre C is zero. $\therefore$

$f_1R = f_2R$ or $\boxed{f_1 = f_2}$

Net torque on cylinder about hinge O is zero.

$\therefore N_2 \times L = N_1 \times L + mgL$

or $N_2 = \boxed{\frac{3mg}{2}}$