PHYSICS

DPP

DAILY PRACTICE PROBLEMS

DPP No. 67

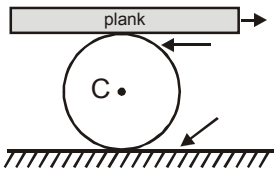
Total Marks : 31

Max. Time : 32 min.

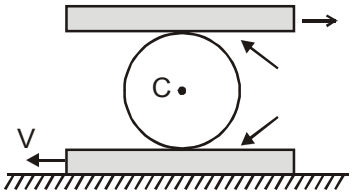
Topics : Rigid Body Dynamics, Center of Mass, Rotation

Type of Questions		M.M., Min.
Single choice Objective ('–1' negative marking) Q.1	(3 marks, 3 min.)	[3, 3]
Subjective Questions ('–1' negative marking) Q.2	(4 marks, 5 min.)	[4, 5]
Comprehension ('–1' negative marking) Q.3 to Q.9	(3 marks, 3 min.)	[21, 21]
Assertion and Reason (no negative marking) Q. 10	(3 marks, 3 min.)	[3, 3]

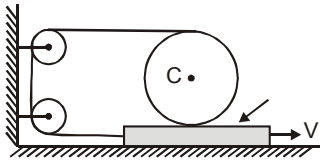
1. There are four arrangements of a solid cylinder and a plank as shown in the figures. Some surfaces are smooth and some are rough as indicated. There is no slipping at each rough surface. The plank and/or centre of cylinder are given a horizontal constant velocity as shown in each of the situations. Using this information fill in the blanks.

(i) 

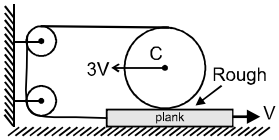
The speed of center of mass of the cylinder is _____.

(ii) 

The angular velocity of the cylinder is _____.

(iii) 

The speed of center of mass of the cylinder is _____ .

(iv) 

The angular velocity of the cylinder is _____ .

(a) V
(b) V/R
(c) 2V/R
(d) 4V/R
(e) cannot be determined from the given information
(f) Zero.

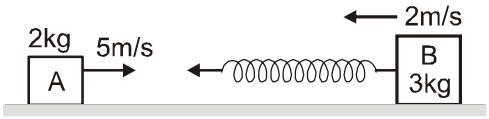
(A) (i) d (ii) b (iii) f (iv) c (B) (i) e (ii) b (iii) f (iv) b (C) (i) e (ii) d (iii) f (iv) c

(D) (i) e (ii) b (iii) f (iv) a (E) (i) e (ii) b (iii) f (iv) d

2. A student throws a horizontal stick of length L up into the air. At the moment it leaves her hand the speed of stick's closest end is zero . The stick completes N turns just as it is caught by the student at the initial release point . Find the height h to which the centre of mass of the rod rises .

COMPREHENSION

In figure, a block A of mass 2kg is moving to the right with a speed 5m/s on a horizontal frictionless surface. Another block B of mass 3 kg with a massless spring of spring constant 222 N/m attached to it, is moving to the left on the same surface and with a speed 2 m/s. Let us take the direction to the right as the positive X–direction. At some instant, block A collides with the spring attached to block B. At some other instant, the spring has maximum compression and then, finally, the blocks move with their final velocities. Assuming that (i) the spring force is conservative and so there is no conversion of kinetic energy to internal energy and (ii) no sound is made when block A hits the spring, answer the following questions.



3. Velocity of centre of mass of the system of blocks A and B, before collision is :

(A) zero (B) $-0.6\hat{i}$ m/s (C) $+0.8\hat{i}$ m/s (D) $1.4\hat{i}$ m/s

4. In the collision process, while the spring is getting compressed :
(A) both linear momentum and kinetic energy are conserved
(B) both linear momentum and mechanical energy are conserved
(C) linear momentum is conserved but mechanical energy is not conserved
(D) Neither the linear momentum nor the mechanical energy remain conserved

5. Final velocity of block A will be :

(A) $2.5\hat{i}$ m/s (B) $-1.8\hat{i}$ m/s (C) $3.6\hat{i}$ m/s (D) $-3.4\hat{i}$ m/s

6. Final velocity of centre of mass of the system of blocks A and B will be :

(A) zero (B) $0.6\hat{i}$ m/s (C) $0.8\hat{i}$ m/s (D) $-1.4\hat{i}$ m/s

7. When the blocks are yet to attain their final velocities, in this situation at any instant when block A is moving with a velocity $4\hat{i}$ m/s, velocity of block B will then be :

(A) $-1.33\hat{i}$ m/s (B) $-2.67\hat{i}$ m/s (C) $1.67\hat{i}$ m/s (D) $3.77\hat{i}$ m/s

8. In previous question, at the given instant, compression of the spring is nearly :
(A) 16 cm (B) 24 cm (C) 33 cm (D) 52 cm

9. Maximum compression of the spring in the collision will be nearly
(A) 30 cm (B) 50 cm (C) 72 cm (D) 36 cm

10. **STATEMENT-1 :** The net momentum of a system of two moving particles is zero. Then at a particular instant of time, the net angular momentum of system of given two particle is same about any point.

STATEMENT-2 : If net momentum of a system of two moving particle is zero, then angular momentum of system of given two particles is zero about any point.
(A) Statement-1 is True, Statement-2 is True; Statement-2 **is** a correct explanation for Statement-1
(B) Statement-1 is True, Statement-2 is True; Statement-2 **is NOT** a correct explanation for Statement-1
(C) Statement-1 is True, Statement-2 is False
(D) Statement-1 is False, Statement-2 is True.

Answers Key

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1. (E) **2.** $\frac{\pi NL}{4}$ **3.** (C) **4.** (B)

5. (D) **6.** (C) **7.** (A) **8.** (C)

9. (B) **10.** (C)

Hint & Solutions

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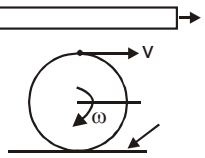
1. (i)



$V_{cm} + \omega R = V \qquad V_{cm} = V - \omega R$

ω depends on value of friction between plank & cylinder, hence V_{cm} is undetermined.

(ii) $\omega = \frac{2v}{2R} = \frac{V}{R}$

(iii) $\omega = \frac{2V}{2R} = \frac{V}{R}$, hence $V_{cm} = 0$

(iv) $\omega_{A/C} = \frac{3V + V}{R} = \frac{4V}{R} \Rightarrow \omega = \frac{4V}{R}$

2. $V_{cm} = \omega \frac{\ell}{2}$

$t = \frac{2V_{cm}}{g} = \frac{\omega \ell}{g}$ time of flight

$T = \frac{2\pi}{\omega}$ time period of one revolution

$t = NT \quad \frac{\omega \ell}{g} = N \frac{2\pi}{\omega}$

$\omega^2 \ell^2 = 2N\pi \ell g$

$$H = \frac{V_{cm}^2}{2g} = \frac{\omega^2 \ell^2}{4 \times 2g} = \frac{2N\pi\ell g}{4 \times 2g} = \frac{N\pi\ell}{4}$$

3. $V_{CM} = \dfrac{m_1\vec{V}_1 + m_2\vec{V}_2}{m_1 + m_2}$ .....(1)

$= \dfrac{(2\times 5 - 3\times 2)}{3+2} = +\dfrac{4}{5}\hat{} = +.8\hat{}$

5. $\frac{1}{2} \times 2 \times 5^2 + \frac{1}{2}(3)2^2 = \frac{1}{2} \times 2\, V_1^2 + \frac{1}{2}\, 3$

$\times V_2^2$ .....(2)

$2(5) - 3(2) = 2V_1 + 3V_2$ .....(3)

$V_1 = -3.4\hat{}$

6. $\vec{V}_{cmfinal} = 0.8\hat{}$

7. $31 = \frac{1}{2}\, 2 \times 4^2 + \frac{1}{2} \times (3)\, V_2^2$

$+ \frac{1}{2}\, kx^2$ .....(4)

$(2)\, 5 - 3\,(2) = 4 \times 2 + 3V_2$ .....(5)

$4 - 8 = 3V_2 - \frac{4}{3} = V_2 \qquad \vec{V}_2 = -1.33\hat{}$

put V_2 in equation (4)

8. x = 33 cm

9. for Max compression

$\frac{1}{2}(2)(5)^2 + \frac{1}{2}\, 3\,(2)^2 = \frac{1}{2}(2+3)(.8)^2 + \frac{1}{2}\, Kx^2$

x = 50 cm

10. $L = r \times p + r \times p \quad \because p \quad p \quad 0$

$= r \quad (p) \quad r \quad p$

$= (r \quad r) \quad p$

$L = r \times p$. Hence Statement-1 is True, Statement-2 is False

$L = r \times p$