PHYSICS

DPP

DAILY PRACTICE PROBLEMS

DPP No. 53

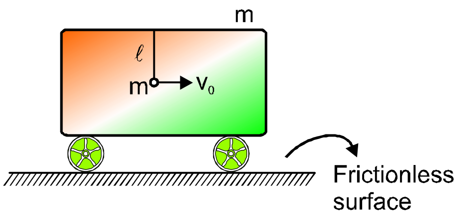
Total Marks : 27

Max. Time : 31 min.

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

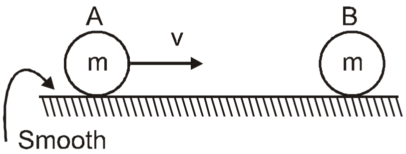
Type of Questions		M.M., Min.
Single choice Objective ('–1' negative marking) Q.1	(3 marks, 3 min.)	[3, 3]
Multiple choice objective ('–1' negative marking) Q.2 to Q.3	(4 marks, 4 min.)	[8, 8]
Subjective Questions ('–1' negative marking) Q.4 to Q.5	(4 marks, 5 min.)	[8, 10]
Match the Following (no negative marking) (2 × 4)Q.6	(8 marks, 10 min.)	[8, 10]

1. A small bob of mass 'm' is suspended by a massless string from a cart of the same mass 'm' as shown in the figure.The friction between the cart and horizontal ground is negligible. The bob is given a velocity V_0 in horizontal direction as shown. The maximum height attained by the bob is, (initially whole system (bob + string + cart) was at rest).



(A) $\frac{2V_0^2}{g}$ (B) $\frac{V_0^2}{g}$ (C) $\frac{V_0^2}{4g}$ (D) $\frac{V_0^2}{2g}$

2. In the figure shown, coefficient of restitution between A and B is e = $\frac{1}{2}$, then :



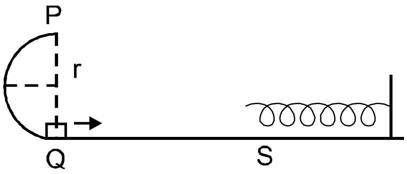
(A) velocity of B after collision is $\frac{v}{2}$

(B) impulse on one of the balls during collision is $\frac{3}{4}$mv

(C) loss of kinetic energy in the collision is $\frac{3}{16}mv^2$

(D) loss of kinetic energy in the collision is $\frac{1}{4}mv^2$

3. The circular vertical section of the fixed track shown is smooth with radius r = 0.9 cm and the horizontal straight section is rough with μ = 0.1. A block of mass 1 kg is placed at point 'Q' and given a horizontal velocity of $\sqrt{3}$ m/s towards the spring. Distance QS = 40 cm and maximum compression in the spring is 10 cm during the motion (g = 10 m/s²) :



(A) The force constant of the spring is 200 N/m

(B) The velocity with which block returns to point 'Q' is 1 m/s

(C) At point P its velocity will be 0.8 m/s

(D) At point P, the normal reaction on the block is less than 55 N

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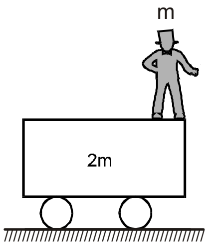
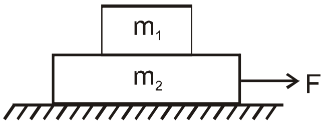
4. The end 'A' of a uniform rod AB of length 'ℓ' touches a horizontal smooth fixed surface. Initially the rod makes an angle of 30° with the vertical. Find the magnitude of displacement of the end B just before it touches the ground after the rod is released.

5. A man is standing on a cart of mass double the mass of the man. Initially cart is at rest on the smooth ground. Now man jumps with relative velocity 'v' horizontally towards right with respect to cart. Find the work done by man during the process of jumping.



6. A small block of mass m_1 lies over a long plank of mass m_2. The plank in turn lies over a smooth horizontal surface. The coefficient of friction between m_1 and m_2 is μ. A horizontal force F is applied to the plank as shown in figure. Column-I gives four situation corresponding to the system given above. In each situation given in column-I, both bodies are initially at rest and subsequently the plank is pulled by the horizontal force F. Take length of plank to be large enough so that block does not fall from it. Match the statements in column-I with results in column-II.



Column-I	Column-II
(A) If there is no relative motion between the block and plank, the work done by force of friction acting on block in some time interval is	(p) positive
(B) If there is no relative motion between the block and plank, the work done by force of friction acting on plank is some time interval	(r) zero
(C) If there is relative motion between the block and plank, then work done by friction force acting on block plus work done by friction acting on plank is	(q) negative
(D) If there is no relative motion between the block and plank, then work done by friction force acting on block plus work done by friction acting on plank is	(s) is equal to non mechanical energy produced

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Answers Key

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

4. $\frac{\sqrt{13}\,\ell}{4}$ **5.** $\frac{mv^2}{3}$

6. (A) p (B) q (C) q, s (D) r

Hint & Solutions

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1. By linear momentum conservation in horizontal direction = for (bob + string + cart)

$mV_0 = (m + m)v$

$$v = \frac{V_0}{2}$$

By mechanical energy conservation for (bob + string + cart + earth)

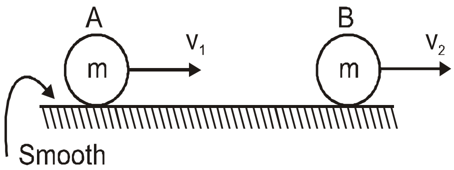
$$\frac{1}{2}mV_0^2 + 0 + 0 = \frac{1}{2}(2m)v^2 + mgh + 0$$

$$\frac{1}{2}mV_0^2 - \frac{1}{2}(2m)\frac{V_0^2}{4} = mgh$$

Solving it,

$$h = \frac{V_0^2}{4g}.$$

2. after collision



By momentum conservation in horizontal direction

$V = V_1 + V_2$ ....(i)

and $e = \frac{V_2 - V_1}{V} = \frac{1}{2}$ ....(ii)

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By (i) and व (ii) $V_2 = \frac{3V}{4}$

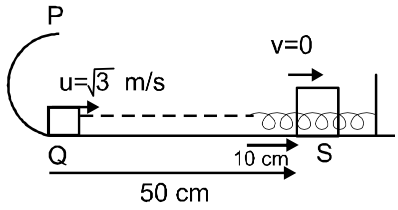
So impulse on B

$= m\left(\frac{3V}{4}\right)$

and loss in K.E.

$= \frac{3}{16} mV^2$

3.



$Q \rightarrow S$

$-\mu mg \times S = 0 + \frac{1}{2}k(0.1)^2 - \frac{1}{2} \times 1 \times (\sqrt{3})^2$

$-0.1 \times 1 \times 10 \times 0.5 = \frac{k}{200} - \frac{3}{2}$

k = 200 N/m

$Q \rightarrow S \rightarrow Q$

$-\mu mg \times 0.5 \times 2 = \frac{1}{2}mv_Q^2 - \frac{1}{2}mu^2$

$-1 = \frac{1}{2} \times 1 \times v_Q^2 - \frac{1}{2} \times 1 \times 3$

$v_Q = 1$ m/s

$Q \rightarrow P$

$v_P^2 = v_Q^2 - 2(g)(2r)$

$v_P = \sqrt{1^2 - 4 \times 10 \times \frac{0.9}{100}} = \frac{8}{10} = 0.8$ m/s

$N_P = \frac{mv_P^2}{r} - mg = \frac{1 \times 64 \times 100}{100 \times 0.9} - 10 = \frac{55}{0.9}$ N.

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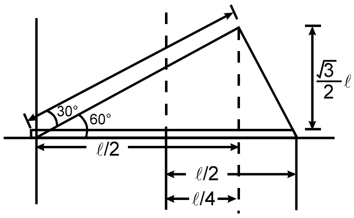
4. Displacement $= \sqrt{\frac{3}{4}\ell^2 + \frac{\ell^2}{16}}$

$= \frac{1}{2}\sqrt{3 + \frac{1}{4}} = \frac{\sqrt{13}\,\ell}{4}$



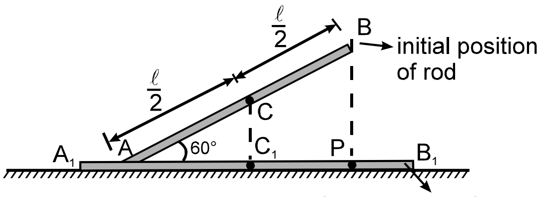
Alternate solution

Initially the rod is at rest

$\therefore u_{cm}$ of rod $= 0$

All forces on rod, act in vertical direction. Hence acceleration of centre of mass is vertically downwards.

$\therefore$ centre of mass of rod moves vertically down wards.



$BP = \ell \sin 60° = \frac{\sqrt{3}}{2}\ell$; $C_1P = \frac{\ell}{2}\cos 60°$

$\therefore PB_1 = B_1C_1 - C_1P = \frac{\ell}{2}(1 - \cos 60°) = \frac{\ell}{4}$

$\therefore$ Displacement of end B is BB_1

$= \sqrt{BP^2 + PB_1^2} = \sqrt{\left(\frac{\sqrt{3}}{2}\ell\right)^2 + \left(\frac{\ell}{4}\right)^2} = \frac{\sqrt{13}\,\ell}{4}$

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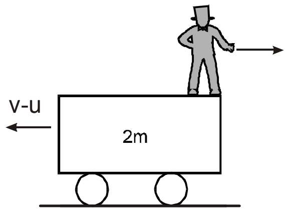
5. Let the velocity of man after jumping be 'u' towards right. Then speed of cart is v-u towards left. From conservation of momentum mu = 2m(v – u)

$\therefore \quad u = \frac{2v}{3}$

hence work done by man = change in K.E. of system



$= \frac{1}{2} mu^2 + \frac{1}{2} 2m (v - u)^2$

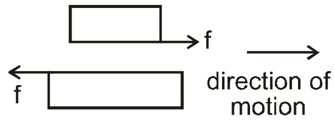
$= \frac{1}{2} m \left(\frac{2v}{3}\right)^2 + \frac{1}{2} 2m \left(\frac{v}{3}\right)^2 \quad = \frac{mv^2}{3}$ **Ans.**

6. (A) p (B) q (C) q, s (D) r

Sol. **(Moderate)** The FBD of block and plank and are shown. Work done on block by friction is positive

Work done on plank by friction is negative.

Work done by friction on plank plus block is zero



when there is no relative motion between them.

Since there is no rubbing between block and plank, mechanical

energy is not lost. (i.e., heat and allied losses are not produced).

Work done by friction on plank + block is negative when there is relative motion between block and plank. This work done is equal loss in mechanical energy of block + plank system.

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