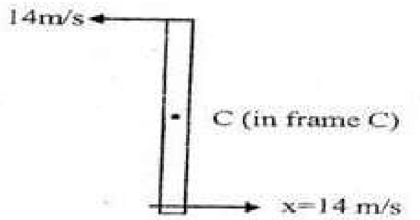
PHYSICS

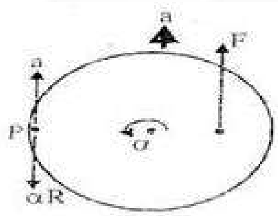


1. $\left(\because F = 0, \tau = 0\right)$

$$14 = \left(\frac{7}{2}\right)w \Rightarrow w = 4rad / sec$$

$$a_A = a_B = \left(\frac{7}{2}\right)w^2 = 56rad / sec^2$$

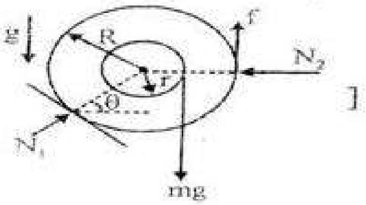
2.



$$F = ma \qquad (i)$$

$$F\frac{R}{2} = \frac{1}{2}mR^2\alpha \qquad (ii)$$

$$a_p = a - \alpha R = 0$$



3.

$$mgr = fR \qquad (i)$$

$$N_1 sin\theta + f = mg \qquad (ii)$$

$$N_1 cos\theta = N_2 \qquad (iii)$$

$$f \le \mu N_2 \qquad (iv)$$

7. For a vertical thread the velocity is maximal since the centre of mass is at its lowest possible position. Then it only remains to apply energy conservation. Interestingly observe that the angular velocity of the rod is zero initially as well as when the thread is vertical.

$$mg\left(\frac{H}{4} - \left(\frac{H-l}{2}\right)\right) = \frac{1}{2}mv^2$$

8. from constraint equation

$x + R\theta = constant$

$\dfrac{dx}{dt} + R\dfrac{d\theta}{dt} = 0$

$\Rightarrow \dfrac{d^2x}{dt^2} + R\dfrac{d^2\theta}{dt^2} = 0$

Where $\dfrac{dx}{dt} = v.$ velocity of hemisphere and $\dfrac{d^2x}{dt^2} = a$ acceleration of hemisphere

$\Rightarrow R\omega = -v \Rightarrow \omega = \dfrac{v}{R}$ [Taking direction into consideration]

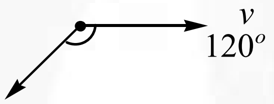
Similarly $\alpha = \dfrac{a}{R}$ [ω & α are angular velocity and acceleration of particle with respect to centre of hemisphere]

Acceleration of particle with respect to centre of hemisphere]

Acceleration of particle with respect to hemisphere is , $a_1 = R\alpha$ & velocity is $v_t = R\omega$

Velocity of particle with respect to ground $\vec{V}PG = \vec{V}PM + \vec{V}HG$

$VPG = \sqrt{v^2 + v^2 + 2v^2 \cos 120} = v$

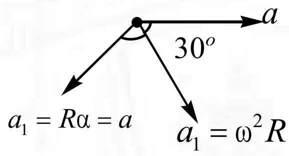


$V = R\omega$

Acceleration of particle with respect to ground .

$\vec{a}PG = \vec{a}PH + \vec{a}HG$

$\Rightarrow a = \sqrt{\left(\dfrac{v^2}{R} + \dfrac{\sqrt{3}a}{2}\right)^2 + \left(\dfrac{a}{2}\right)^2}$

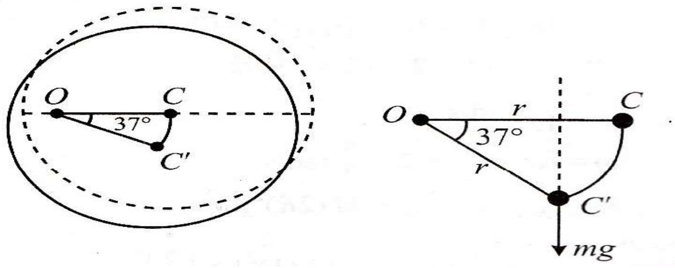


9. $K.E. of\ ball = \dfrac{1}{2}mv^2 + \dfrac{1}{2}\left(\dfrac{2}{5}mr^2\right)\left(\dfrac{2v}{r}\right)^2 + mgh = \dfrac{mv^2}{2} + \dfrac{4}{5}mv^2 + mgh = 2mgh$

10. $X = 2vt = 2v\sqrt{\dfrac{2h}{g}} = 2.\sqrt{\dfrac{5}{9}gh}\sqrt{\dfrac{2h}{g}} = \dfrac{2\sqrt{10}}{3}h$

13. a, 14. c

Sol. From $\tau = I\alpha$,



$$Mg \times r\cos 37^o = \left[\frac{MR^2}{2} + Mr^2\right]\alpha$$

$$\alpha = \frac{8rg}{5\left[R^2 + 2r^2\right]}$$

From energy conservation,

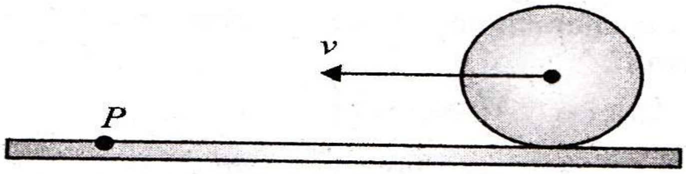
$$\frac{I\omega^2}{2} = Mg \times r\sin 37^o$$

$$\left[\frac{MR^2}{2} + Mr^2\right]\frac{\omega^2}{R} = Mgr \times \frac{3}{5}$$

$$\omega = \sqrt{\frac{12gr}{5\left[R^2 + 2r^2\right]}}$$ For FBD of the disc

15, 16: in reference frame of truck, the angular momentum is conserved about P, i.e.,

$$MvR = Mv_0R + \frac{2}{5}MR^2\omega_0$$



Rolling constraint

$$v = R\omega \qquad \text{(ii)}$$

On solving Eqs (i) and (ii) we get $v = \frac{5}{7}v_0$

Note that v_0 is the speed in truck frame: in ground frame, the velocity is

$v_0 - (5v_0/7) = 2v_0/7$ towards the right

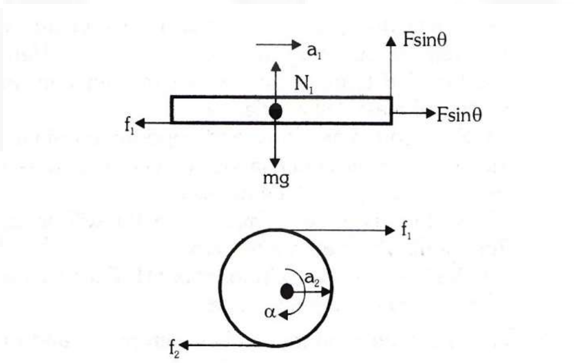
Answer is independent of M or R.

17. The FBD & various parameters are shown in figure. From various dynamics equation

$$F\cos\theta - f_1 = ma_1$$

$$f_1 - f_2 = Ma_2$$

$$\alpha = \frac{(f_1+f_2)R}{\frac{1}{2}MR^2}$$



Solving above equation we get

$$a_2 = \frac{4F\cos\theta}{[3M+8m]}, f_1 = \frac{3MF\cos\theta}{[3M+8m]}$$

$$a_1 = \frac{8F\cos\theta}{[3M+8m]}, f_2 = \frac{3MF\cos\theta}{[3M+8m]}$$