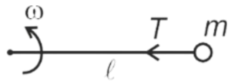
S1. Ans. (b)

$F = (M_1 + M_2)a$

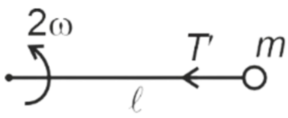
$a = \frac{10}{2+3} = 2\ ms^{-2}$

$F = M_2(2) = 3 \times 2\ N = 6\ N.$

S2. Ans. (a)



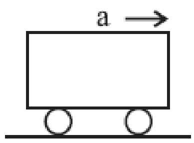
$T = m\ell\omega^2$



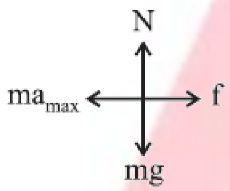
$T' = m\ell(2\omega)^2$

$T' = 4\,T.$

S3. Ans. (d)



In the frame of car



$N = mg$

and $f = ma$

$f \leq \mu N$

$\Rightarrow a \leq \mu g$

$\Rightarrow a \leq 1.5\ ms^{-2}$

or $a_{max} = 1.5\ ms^{-2}$

S4. Ans. (c)

Given, mass of the shell = m

Ratio of masses of the fragments is 2 : 2 : 1

Therefore, masses of three fragments are

$m_1 = \frac{m}{2}, m_2 = \frac{m}{2}$ and $m_3 = \frac{m}{4}$

Now fragments with equal masses i.e. m_1 and m_2 fly off perpendicularly with speeds $v_1 = v_2 = v$. Let the velocity of third fragment be v'.

Applying law of conservation of momentum,

$m_1 v_1 \hat{\imath} + m_2 v_2 \hat{\jmath} + m_3 \vec{v} = 0$

$\frac{mv}{2}\hat{\imath} + \frac{mv}{2}\hat{\jmath} + \frac{mv}{2}\vec{v}' = 0 \Rightarrow \vec{v}' = 2v(-\hat{\imath} - \hat{\jmath})$

$|\vec{v}| = 2v\sqrt{(-1)^2 + (-1)^2} = 2\sqrt{2}v$

S5. Ans. (a)

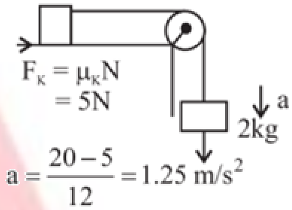
Hint: $\frac{S_n}{S_{n+1}} = \frac{\frac{a}{2}(2n-1)}{\frac{a}{2}(2(n+1)-1)} = \frac{2n-1}{2n+2-1} = \frac{2n-1}{2n+1}$

S6. Ans. (b)

Hint: $a = \frac{(m_2 - m_1)g}{m_1 + m_2}$ $\quad a = \frac{(6-4)g}{6+4} = \frac{2g}{10} = \frac{g}{5}$

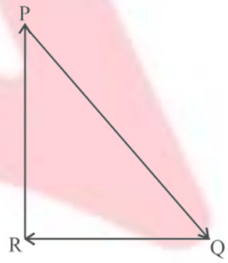
S7. Ans. (d)

Hint:



S8. Ans. (c)

Hint:



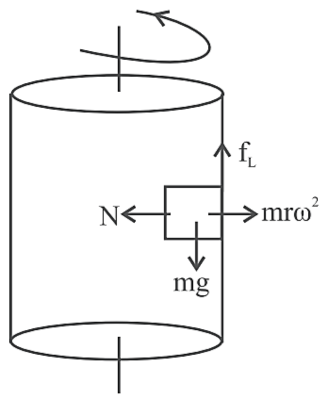
All these forces are forming closed loop in same order. So, net force is zero

Force = ma

$\Rightarrow m\frac{d\vec{v}}{dt} = 0 \Rightarrow \vec{v}$ constant

S9. Ans. (c)

Hint:



For equilibrium of the block limiting friction

$f_L \geq mg$

$\Rightarrow \mu N \geq mg$

$\Rightarrow \mu m r \omega^2 \geq mg$

$\omega \geq \sqrt{\frac{g}{r\mu}}$

Therefore,

$\omega_{min} = \sqrt{\frac{g}{r\mu}}$

$\omega_{min} = \sqrt{\frac{10}{0.1\times1}} = 10\, rad/s$

S10. Ans. (d)

Hint: Coefficient of sliding friction is dimensionless

S11. Ans. (d)

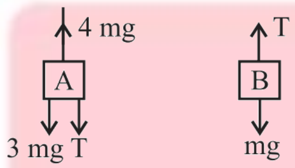
Hint: From wedge reference frame

For block to be at rest

ma $cos\theta = mg \sin\theta$

$a = g \tan\theta$

S12. Ans. (d)



When the string is cut T = 0

for block A

3 m a = 4 mg – 3 mg

$a = \frac{g}{3}$ for block B

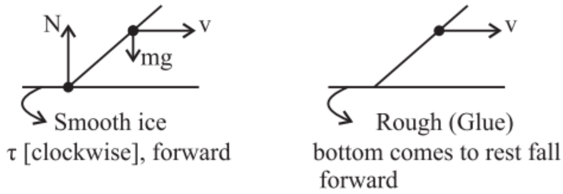
mg = ma ⇒ a = g

S13. Ans. (d)

Hint: In uniform circular motion, tension provides the necessary centripetal force required to keep particle in motion.

S14. Ans. (b)

Hint:



S15. Ans. (b)

Hint: $V_{max} = \sqrt{\mu r g}$

$= \sqrt{0.2 \times 3 \times 10}$

$= \sqrt{6}\ ms^{-1}$

$= \frac{\sqrt{6}\times 18}{5}\frac{km}{h} = 8.8\ km\ h^{-1}$

Only 7.2 kmh^{-1} in the options is less than

8.8 $km\ h^{-1}$ so option b is the correct answer.

S16. Ans. (b)

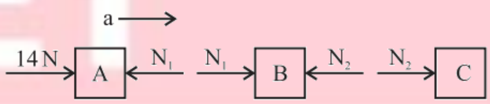
Hint: We know that $\frac{v^2}{gR} = \left(\frac{\mu_s + tan\theta}{1-\mu_s\ tan\theta}\right)$

$v = \sqrt{gR\left(\frac{\mu_s + tan\theta}{1-\mu_s\ tan\theta}\right)}$

S17. Ans. (a)

Hint: Acceleration of system $= \frac{F_{net}}{M_{total}}$

$= \frac{14}{4+2+1} = 2\ ms^{-2}$



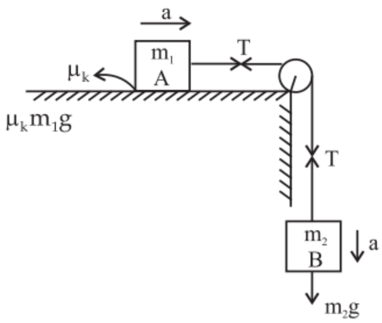
N_1 = Normal force between A and B

14 - N_1 = $m_A a$

14 - N_1 = 4 × 2

14 - N_1 = 8 ⇒ N_1 = 6 N

S18. Ans. (b)



For the motion of both blocks

$m_2 g - T = m_2 a$

$T - \mu_k m_1 g = m_1 a \Rightarrow a = \frac{(m_2 - \mu_k m_1)g}{m_1 + m_2}$

For the block of mass $'m_2'$

$m_2 g - T = m_2 \left[\frac{m_2 - \mu_k m_1}{m_1 + m_2}\right] g$

$T = m_2 g - \left[\frac{m_2 - \mu_k m_1}{m_1 + m_2}\right] m_2 g = m_2 g \left[\frac{m_2 + \mu_k m_1}{m_1 + m_2}\right]$

$\Rightarrow T = \frac{m_1 m_2 (1 + \mu_k) g}{m_1 + m_2}$

S19. Ans. (b)

Hint: $(F_C)_{heavier} = (F_C)_{lighter}$

$\Rightarrow \frac{2mV^2}{(r/2)} = \frac{m\,(nV)^2}{r} \Rightarrow n^2 = 4 \Rightarrow n = 2$

S20. Ans. (c)

Hint: Coefficient of static friction

$\mu_s = \tan 30° = \frac{1}{\sqrt{3}} = 0.6$

$a = g \sin 30° - \mu_k\, g \cos 30°$

$S = ut + \frac{1}{2} a t^2 \quad [\because u = 0]$

$\Rightarrow 4 = \frac{1}{2}\left[\frac{g}{2} - \frac{\mu_k g \sqrt{3}}{2}\right] \times 16 \Rightarrow \mu_k = 0.5$

S21. Ans. (a)

Hint:

For downward motion

$mg - F_a = ma \Rightarrow F_a = mg - ma$

If some mass Δ m is removed, then it starts accelerating upwards

$F_a - (m - \Delta m)g = (m - \Delta m)a$

mg – mg – mg + gΔm = ma – a Δ m

gΔm - ma = ma – aΔm ⇒ Δm [g + a] = 2 ma

$\Delta m = \frac{2ma}{g + a}$

S22. Ans. (c)

Hint: Change in momentum,

$\int \Delta p = \int \text{Fdt} = \text{Area of F} - \text{t grah}$

$= \frac{1}{2} \times 2 \times 6 - 3 \times 2 + 4 \times 3 = 12$ Ns

S23. Ans. (c)

Hint: Acceleration = $\frac{\text{Net force in the direction of motion}}{\text{Total mass of system}}$

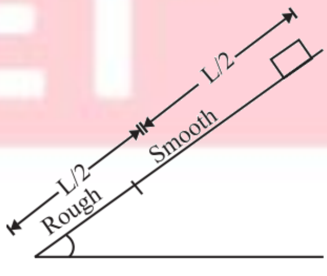
$= \frac{m_1 g - \mu(m_2 + m_3)g}{m_1 + m_2 + m_3} = \frac{g(1 - 2\mu)}{3} [\because m_1 = m_2 = m_3]$

S24. Ans. (b)

Hint: As block of mass 2m moves with constant velocity so net force on it is zero.

S25. Ans. (a)

Hint:



Let m be mass of the block and L be length of the inclined plane.

For upper half smooth plane

Acceleration of the block, a = g sin θ

Here, u = 0 (∵ block starts from rest)

Using, $v^2 - u^2$ = 2as, we have

$v^2 - 0 = 2 \times g\ sin\theta \times \frac{L}{2}$

$v = \sqrt{gLsin\theta}$ ....(1)

For lower half rough plane Acceleration of the block, a' = gsin θ – μgcos θ where μ is the coefficient of friction between the block and lower half of the plane

Here, $u = v = \sqrt{gL\ sin\theta}$

v = 0 ($\because$ *block comes to rest*)

a = a' = gsin θ – μgcos θ, $s = \frac{L}{2}$

Again, using v^2 – u^2 = 2as, we have

$$0 - \left(\sqrt{gL\ sin\theta}\right)^2 = 2 \times (g \sin\theta - \mu g \cos\theta) \times \frac{L}{2}$$

–gLsin θ = (gsin θ – μg cos θ)L

–sin θ = sin θ – μ cos θ

μ cos θ = 2sin θ ⇒ μ = 2tan θ