DPP – 3

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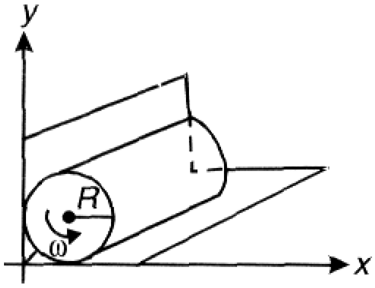
Video Solution on YouTube:- https://youtu.be/5cTpO2GDiGs

Written Solution on Website:- https://physicsaholics.com/note/notesDetalis/18

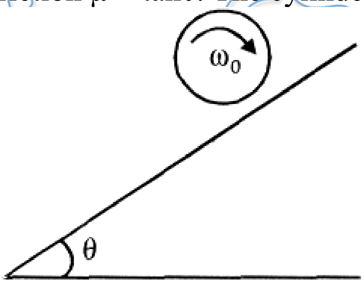
Q 1. A uniform cylinder of radius R is spinned with angular velocity ω about its axis and then placed into a corner. The coefficient of friction between cylinder and planes is μ. The number of turns taken by cylinder before stopping is given by



(a) $\frac{R(1+\mu)\omega^2}{8\pi\mu g}$ (b) $\frac{R(1+\mu^2)\omega^2}{8\pi\mu g(1+\mu)}$

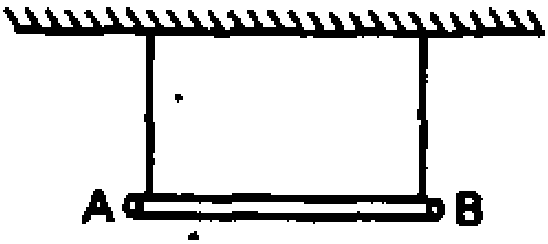
(c) $\frac{R(1+\mu^2)\omega^2}{4\pi\mu g(1+\mu)}$ (c) $\frac{R(1+\mu^2)\omega^2}{\mu g(1+\mu)}$

Q 2. A solid cylinder of radius R is spinned and then placed on an incline having coefficient of friction μ = tanθ. The cylinder continues to spin without falling for time



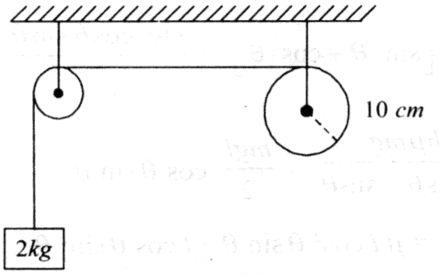
(a) $\frac{R\omega_0}{3gSin\theta}$ (b) $\frac{R\omega_0}{2gSin\theta}$ (c) $\frac{R\omega_0}{gSin\theta}$ (d) $\frac{2R\omega_0}{gSin\theta}$

Q 3. A uniform rod of mass in and length *l* is suspended by means of two light inextensible strings as shown in figure. Tension in one string immediately after the other string is cut is:



(a) $\frac{mg}{2}$ (b) 2 mg (c) $\frac{mg}{4}$ (d) mg

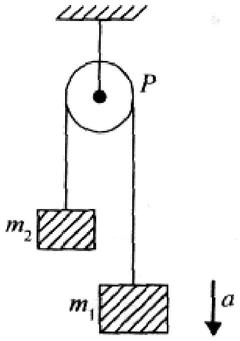
Q 4. A spring wrapped on a wheel of MOI 0.2 kg m^2 and radius 10 cm over a light pulley to support a block of mass 2 kg as shown in fig. Find the acceleration of the block.



(a) 0.89 ms^{-2} (b) 1.12 ms^{-2} (c) 0.69 ms^{-2} (d) None

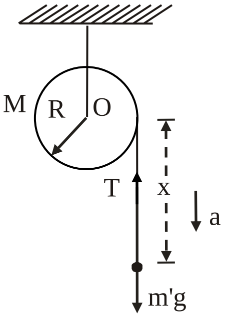
Q 5. Two men support a uniform horizontal beam at its two ends. If one of them suddenly lets go, the force exerted by the beam on the other man will
(a) remain unaffected.
(b) increase.
(c) decrease.
(d) become unequal to the force exerted by him on the beam.

Q 6. In the figure, the blocks have unequal masses m_1 and m_2 ($m_1 > m_2$). m_1 has a downward acceleration a. The pulley P has a radius r, and some mass. The string does not slip on the pulley.



(a) The two sections of the string have unequal tensions.
(b) The two blocks have accelerations of equal magnitude.
(c) The angular acceleration of P is air.
(d) a < $\left(\frac{m_1-m_2}{m_1+m_2}\right) g$.

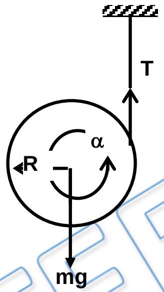
Q 7. A uniform cylinder of radius R and mass M can rotate freely about a stationary horizontal axis O as shown in figure. A thin cord of length l and mass m is wound on the cylinder in a single layer. Find the angular acceleration of the cylinder as a function of the length x of the hanging part of the cord. The wound part of the cord is supposed to have its centre of gravity on the cylinder axis.



(a) $\frac{2mgx}{(2m+M)R}$ (b) $\frac{4mgx}{(2m+M)R}$

(c) $\frac{2mgx}{(4m+M)R}$ (d) $\frac{mgx}{(2m+M)R}$

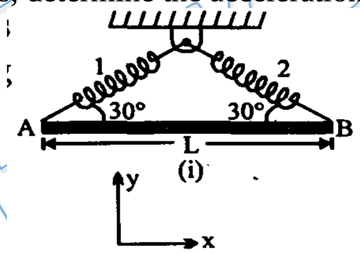
Q 8. A string is wrapped several times round a solid cylinder and then the end of the string is held stationary while the cylinder is released from rest with an initial motion. The acceleration of the cylinder and tension in the string will be



(a) 2g/3 and mg/3 (b) g and mg/2

(c) g/3 and mg/2 (d) g/2 and mg/3

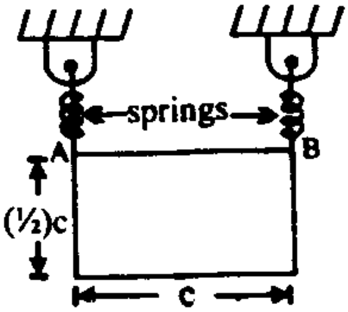
Q 9. A uniform slender bar AB of mass m is suspended from two springs as shown. If spring 2 breaks, determine the acceleration of point B at that instant.



(a) g (b) 2g

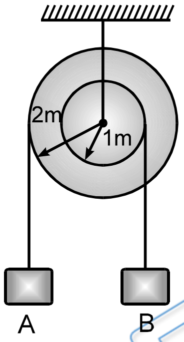
(c) g/2 (d) None of these

Q 10. A uniform plate is hanging with the help of two strings as shown. Find angular acceleration of plate just after breaking connection of spring at B ?



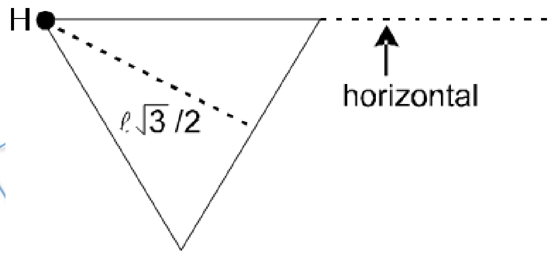
(a) g/5c (b) 4g/5c (c) 12g/5c (d) g/c

Q 11. In the pulley system shown, if radii of the bigger and smaller pulley are 2 m and 1 m respectively and the acceleration of block A is 5 m/s2 in the downward direction, then the acceleration of block B will be:



(a) 0 m/s^2 (b) 5 m/s^2 (c) 10 m/s^2 (d) 5/2 m/s^2

Q 12. A rigid equilateral triangular frame made of three identical thin rods (mass = m & length = l) is free to rotate smoothly in vertical plane. Frame is hinged at one of its vertices H. Frame is released from rest from the position shown in figure then select correct alternative (s).



(a) Net initial torque about point H is $\frac{3}{2}$ mgl

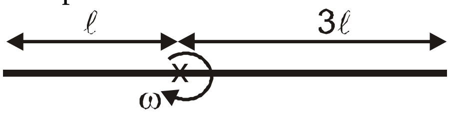
(b) Initial angular acceleration of the frame is g/l

(c) Initial force of hinge on the frame is 3 mg

(d) Initial force of hinge on the frame is $\sqrt{3}$mg

Comprehension (Q.13 to Q.14)

A thin uniform rod having mass m and length 4l is free to rotate about horizontal axis passing through a point distant l from one of its end, as shown in figure. It is released, from the horizontal position as shown:



Q 13. What will be normal reaction due to hinge at the instant of release:

(a) mg (b) $\frac{mg}{2}$

(c) $\frac{4mg}{7}$ (d) $\frac{\sqrt{2}mg}{7}$

Q 14. Mark out the correct options:

(a) Angular acceleration about hinge at this instant is $\frac{3g}{7\ell}$

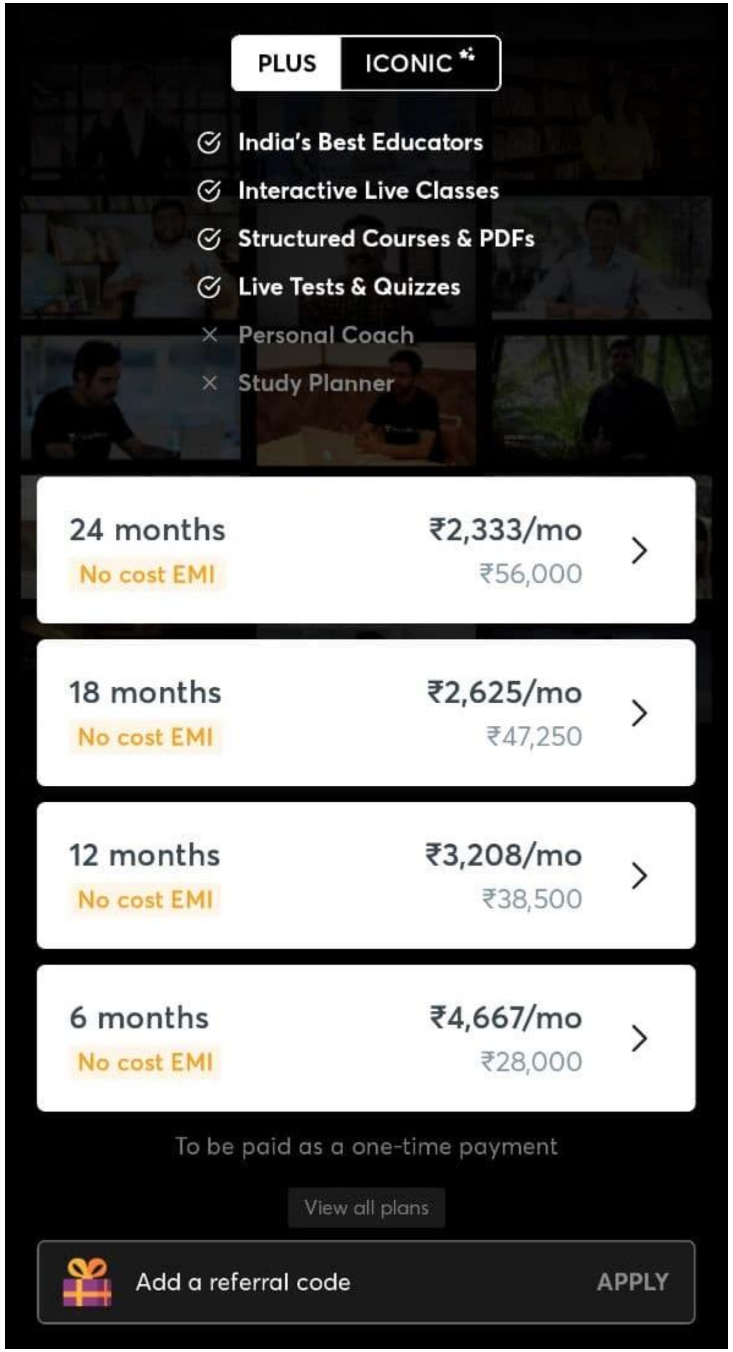
(b) Net torque about hinge at this instant will be $\frac{7}{5}mg\ell$

(c) Net torque about hinge at this instant will be mgl

(d) None of these

Answer Key

Q.1 b	**Q.2 b**	**Q.3 c**	**Q.4 a**	**Q.5 c**
Q.6 a, b, c, d	**Q.7 a**	**Q.8 a**	**Q.9 d**	**Q.10 c**
Q.11 d	**Q.12 a, b, d**	**Q.13 c**	**Q.14 a, c**	



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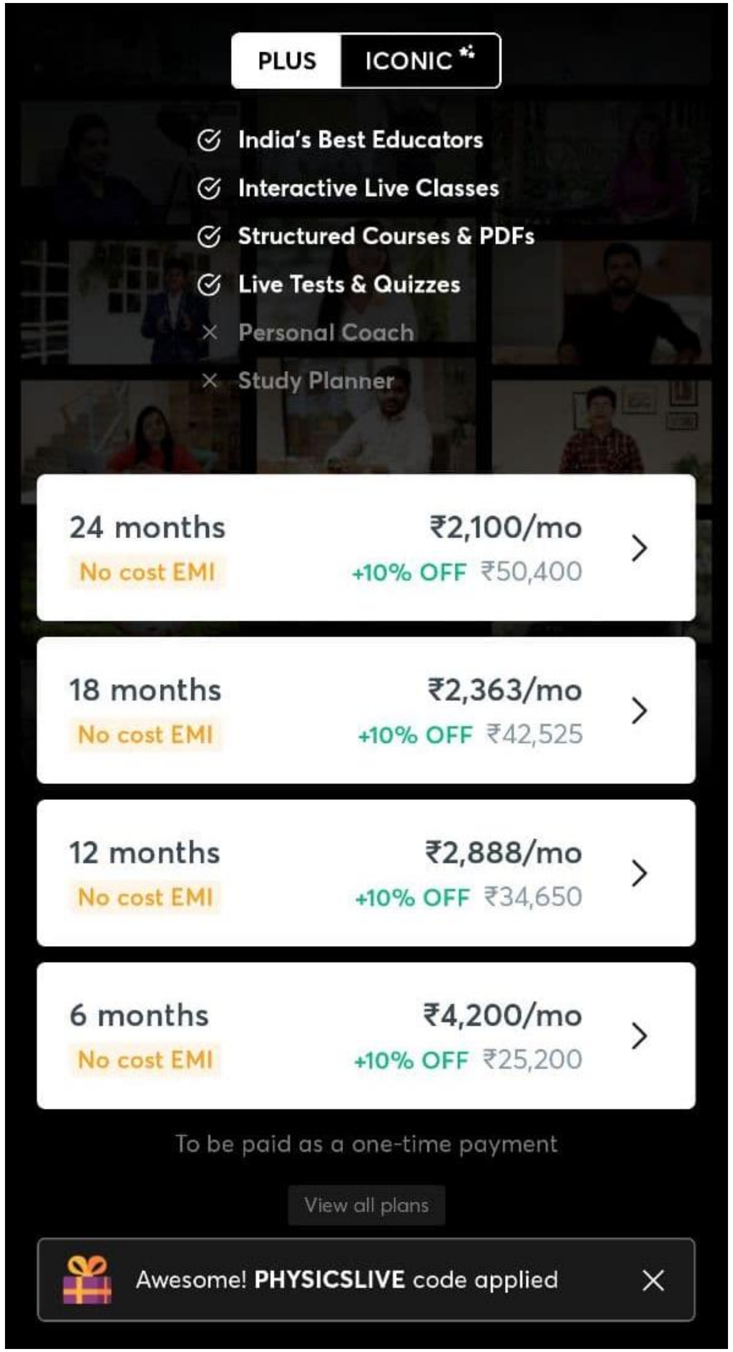

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Written Solution

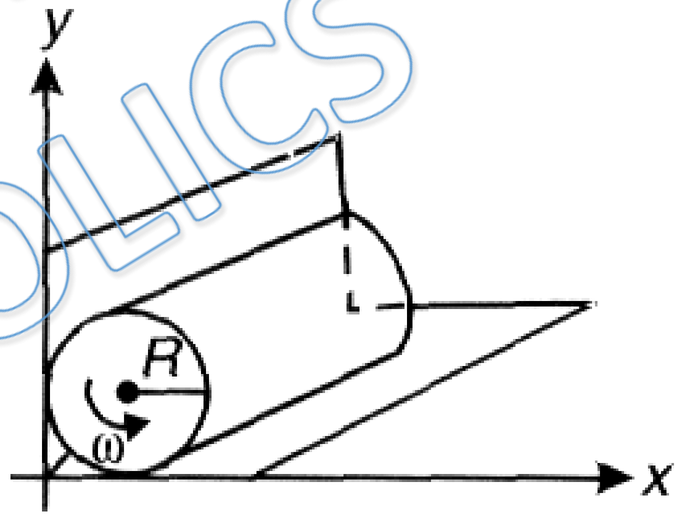
JEE Main & Advanced, NSEP, INPhO, IPhO

Physics DPP

DPP- 3 Rotation: Relation between Torque & Moment of inertia

By Physicsaholics Team

Q1) A uniform cylinder of radius R is spinned with angular velocity ω about its axis and then placed into a corner. The coefficient of friction between cylinder and planes is μ. The number of turns taken by cylinder before stopping is given by



(a) $\frac{R(1+\mu)\omega^2}{8\pi\mu g}$

(b) $\frac{R(1+\mu^2)\omega^2}{8\pi\mu g(1+\mu)}$

(c) $\frac{R(1+\mu^2)\omega^2}{4\pi\mu g(1+\mu)}$

(c) $\frac{R(1+\mu^2)\omega^2}{\mu g(1+\mu)}$

Ans. b

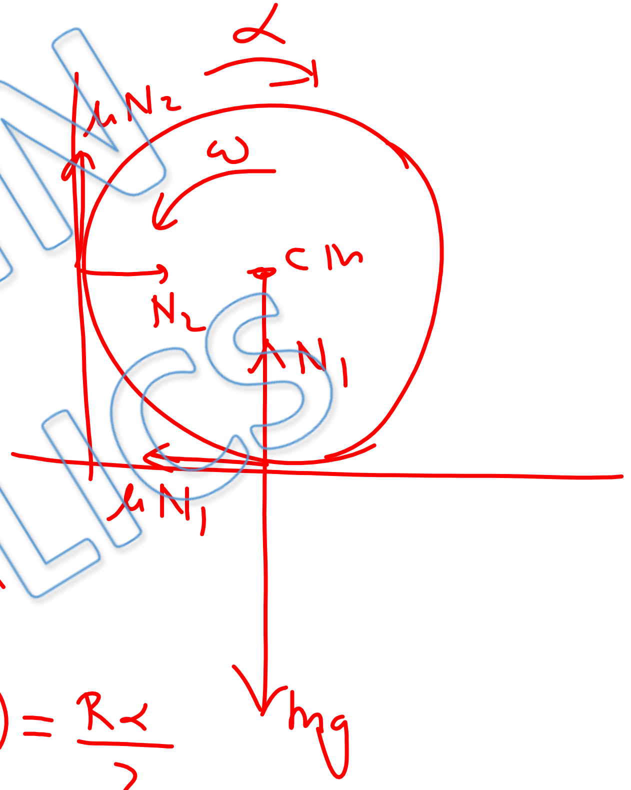
$n \rightarrow$ no of rotations $\Rightarrow \theta = 2n\pi$

$$N_2 = \mu N_1 \quad \text{--- (i)}$$

$$N_1 + \mu N_2 = mg \quad \text{--- (ii)}$$

$$N_1(1+\mu^2) = mg$$

$$N_1 = \frac{mg}{1+\mu^2}, \quad N_2 = \frac{\mu mg}{1+\mu^2}$$



$$\tau_{cm} = I_{cm}\alpha \Rightarrow \mu N_1 R + \mu N_2 R = \frac{mR^2}{2}\alpha$$

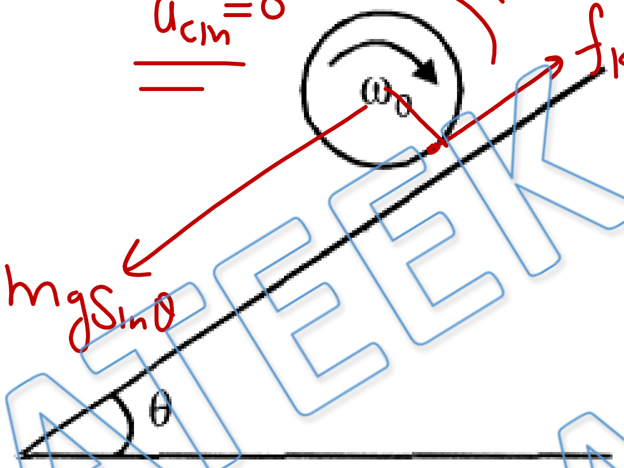
$$\Rightarrow \mu\left(\frac{mg}{1+\mu^2} + \frac{\mu mg}{1+\mu^2}\right) = \frac{mR\alpha}{2} \Rightarrow \frac{g\mu}{1+\mu^2}(1+\mu) = \frac{R\alpha}{2}$$

$$\alpha = \frac{2g\mu(1+\mu)}{R(1+\mu^2)}$$

$$\omega^2 = \omega_0^2 + 2\alpha\theta \Rightarrow 0 = \omega^2 - \frac{2 \times 2g\mu(1+\mu)}{R(1+\mu^2)} \times 2n\pi$$

$$n = \frac{R(1+\mu^2)\omega^2}{8\pi g\mu(1+\mu)}$$

Q2) A solid cylinder of radius R is spinned and then placed on an incline having coefficient of friction $\mu = \tan\theta$. The cylinder continues to spin without falling for time



$a_{cm} = 0$

$f_k = \mu mg\cos\theta = mg\sin\theta$

$\tau_{cm} = I_{cm}\alpha$

$\Rightarrow mg\sin\theta\, R = \frac{mR^2}{2}\alpha$

$\alpha = \frac{2g\sin\theta}{R}$

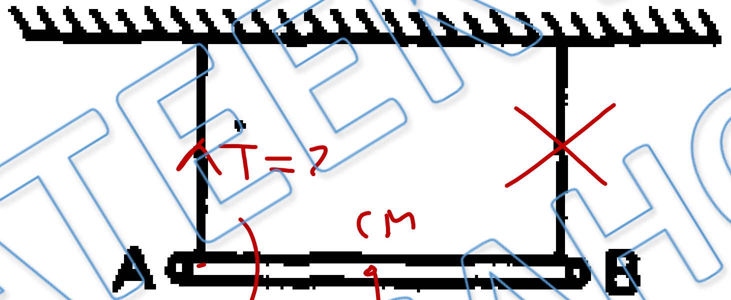
$\omega = \omega_0 + \alpha t$

$0 = \omega_0 - \frac{2g\sin\theta}{R}t$

$t = \frac{\omega_0 R}{2g\sin\theta}$

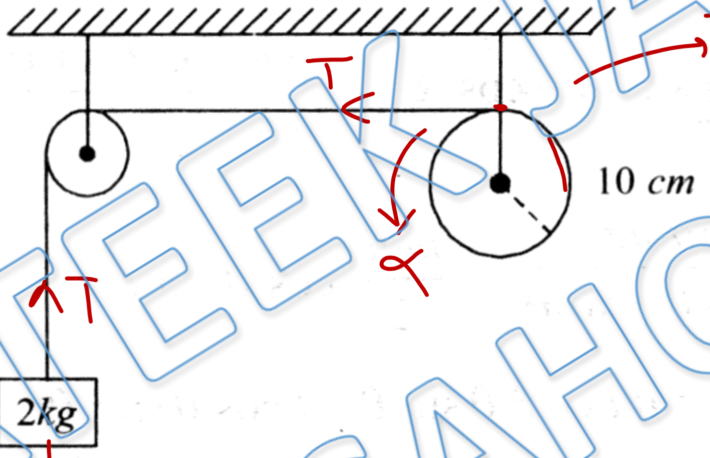
(a) $\frac{R\omega_0}{3gSin\theta}$ (b) $\frac{R\omega_0}{2gSin\theta}$ (c) $\frac{R\omega_0}{gSin\theta}$ (d) $\frac{2R\omega_0}{gSin\theta}$

Q3) A uniform rod of mass in and length l is suspended by means of two light inextensible strings as shown in figure. Tension in one string immediately after the other string is cut is:



(a) $\frac{mg}{2}$ (b) 2 mg (c) $\frac{mg}{4}$ (d) mg

Q4) A spring wrapped on a wheel of MOI 0.2 kg m^2 and radius 10 cm over a light pulley to support a block of mass 2 kg as shown in fig. Find the acceleration of the block.



$a = \alpha R$ --- (I)

$20 - T = 2a$ --- (II)

$T \times (\frac{1}{10}) = .2\,\alpha$

$T = 2\alpha$ --- (III)

$\alpha = \frac{a}{R} = 10a$

$I = .2\ kg\,m^2$

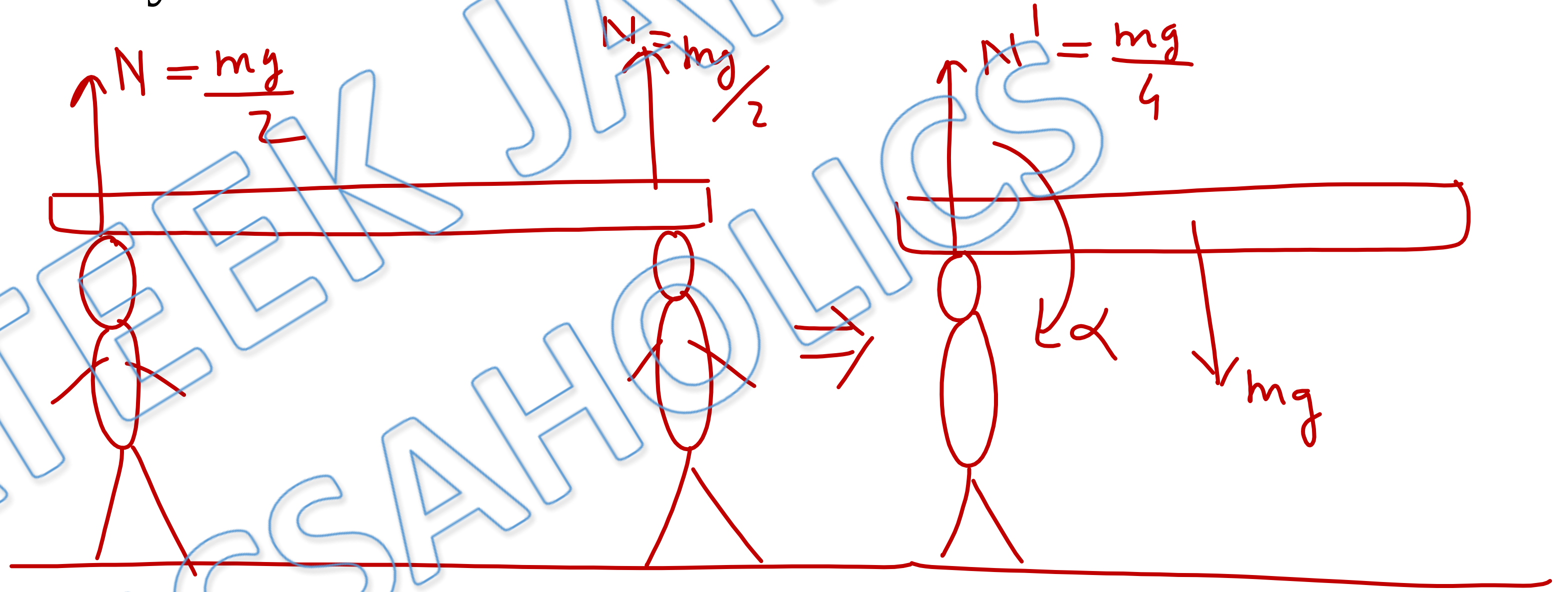
(a) 0.89 ms-2 (b) 1.12 ms^{-2} (c) 0.69 ms^{-2} (d) None

$20 - 2\alpha = 2a$

$20 = 22a$

$a = \frac{20}{22} = \frac{10}{11}$ m/sec^2

Q5) Two men support a uniform horizontal beam at its two ends. If one of them suddenly lets go, the force exerted by the beam on the other man will



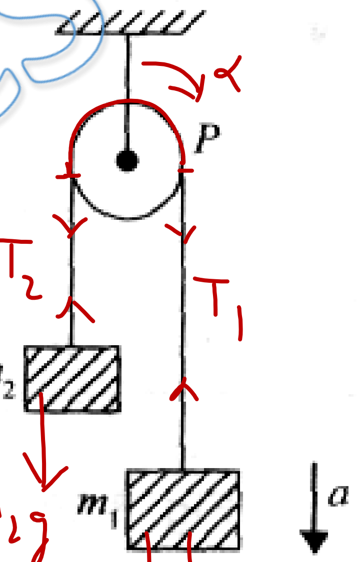
(a) remain unaffected.

(b) increase.

(c) decrease.

(d) become unequal to the force exerted by him on the beam.

Q6) In the figure, the blocks have unequal masses m_1 and m_2 ($m_1 > m_2$). m_1 has a downward acceleration a. The pulley P has a radius r, and some mass. The string does not slip on the pulley.



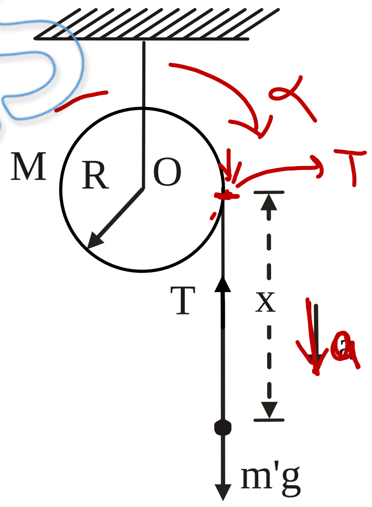
(a) The two sections of the string have unequal tensions.

(b) The two blocks have accelerations of equal magnitude.

(c) The angular acceleration of P is a/r.

(d) $a < \left(\frac{m_1 - m_2}{m_1 + m_2}\right) g$.

Q7) A uniform cylinder of radius R and mass M can rotate freely about a stationary horizontal axis O as shown in figure. A thin cord of length l and mass m is wound on the cylinder in a single layer. Find the angular acceleration of the cylinder as a function of the length x of the hanging part of the cord. The wound part of the cord is supposed to have its centre of gravity on the cylinder axis.



(a) $\frac{2mgx}{(2m+M)l}$ ✓

(b) $\frac{4mgx}{(2m+M)l}$

(c) $\frac{2mgx}{(4m+M)l}$

(d) $\frac{mgx}{(2m+M)l}$

$$a = R\alpha \quad \text{--- (I)}$$

$$\frac{m}{l} x g - T = \frac{m}{l} x a \quad \text{--- (II)}$$

$$T R = \left[\frac{MR^2}{2} + \frac{m}{l}(l-x)R^2\right]\alpha$$

$$T = \left[\frac{M}{2} + \frac{m}{l}(l-x)\right]a \quad \text{--- (III)}$$

$$\frac{mgx}{l} = a\left[\frac{M}{2} + m - \frac{mx}{l} + \frac{mx}{l}\right]$$

$$a = \frac{mgx}{l\left(\frac{M}{2}+m\right)} = \frac{2mgx}{l(M+2m)}$$

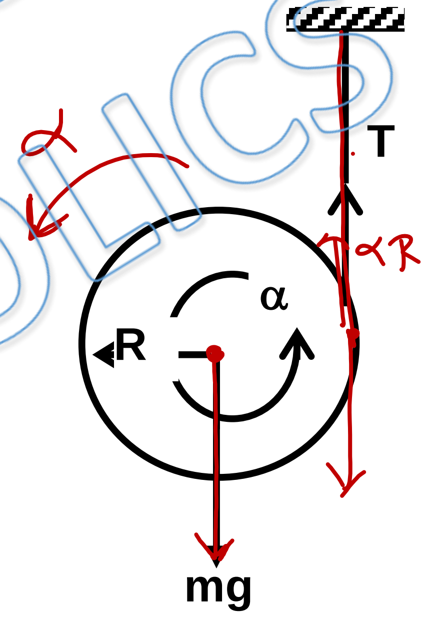
Q8) A string is wrapped several times round a solid cylinder and then the end of the string is held stationary while the cylinder is released from rest with an initial motion. The acceleration of the cylinder and tension in the string will be

$a = \alpha R$ — (I)

$mg - T = ma$ — (II)

$TR = \frac{mR^2}{2}\alpha$ — (III)

$T = \frac{ma}{2}$



(a) 2g/3 and mg/3 ✓

(b) g and mg/2

(c) g/3 and mg/2

(d) g/2 and mg/3

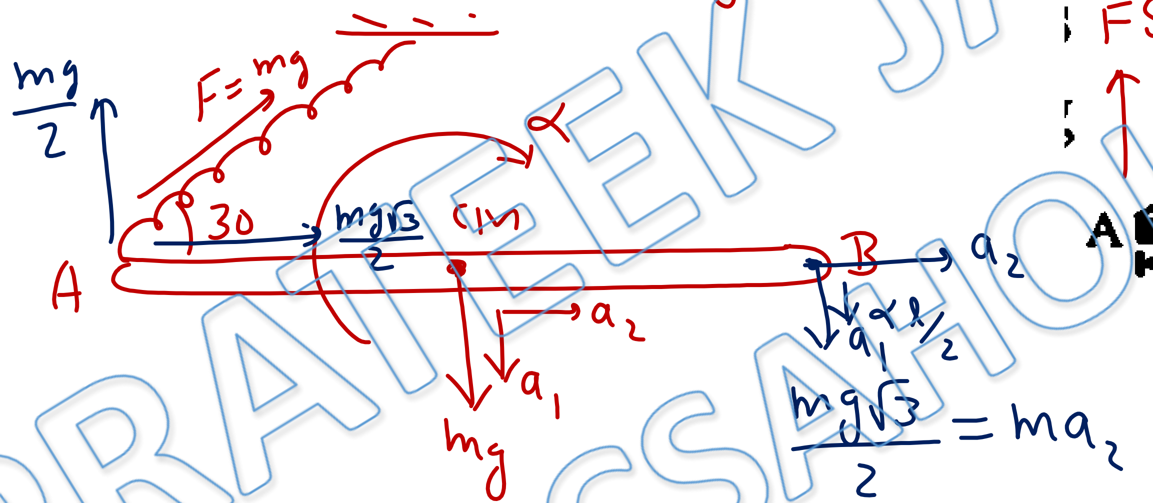
$mg - \frac{ma}{2} = ma$

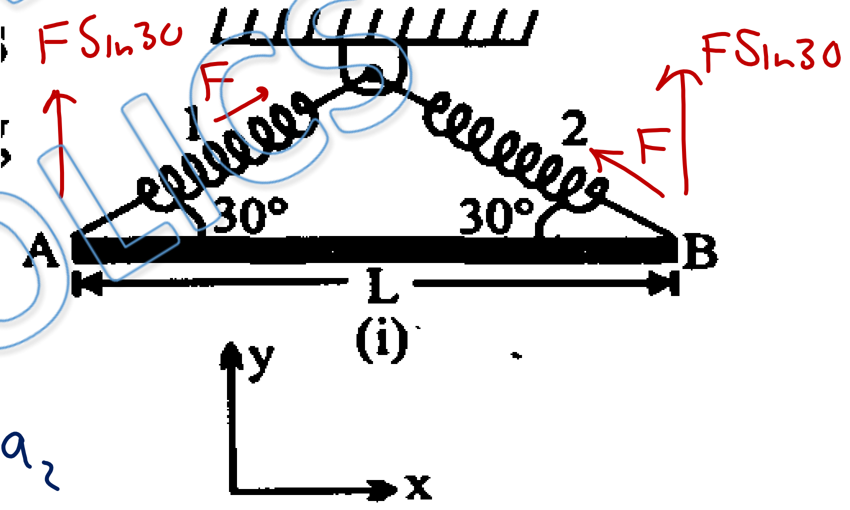
$\frac{3ma}{2} = mg \Rightarrow a = 2g/3$

$T = \frac{m}{2} \times \frac{2g}{3}$

Q9) A uniform slender bar AB of mass m is suspended from two springs as shown. If spring 2 breaks, determine the acceleration of point B at that instant.

$2F\sin 30 = mg \Rightarrow F = mg$





(a) g

(b) 2g

(c) g/2

(d) None of these

$\frac{mg\sqrt{3}}{2} = ma_2$

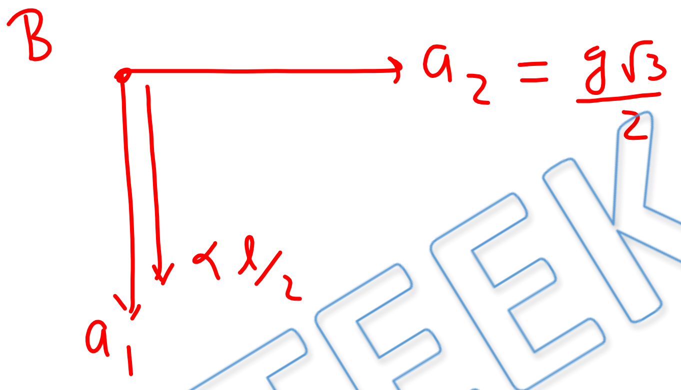
$a_2 = \frac{g\sqrt{3}}{2}$ — (I)

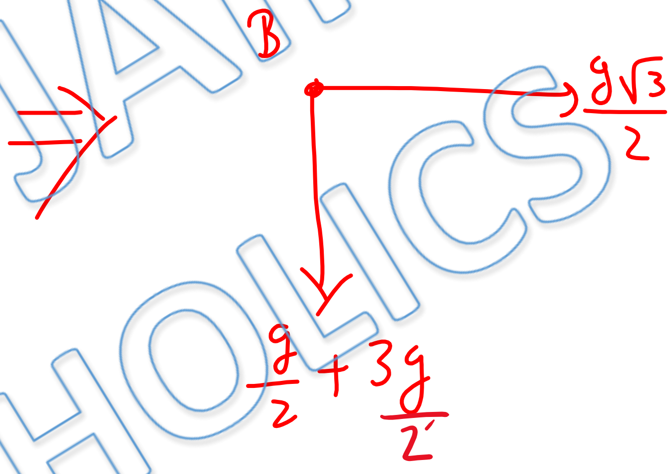
$mg - \frac{mg}{2} = ma_1$

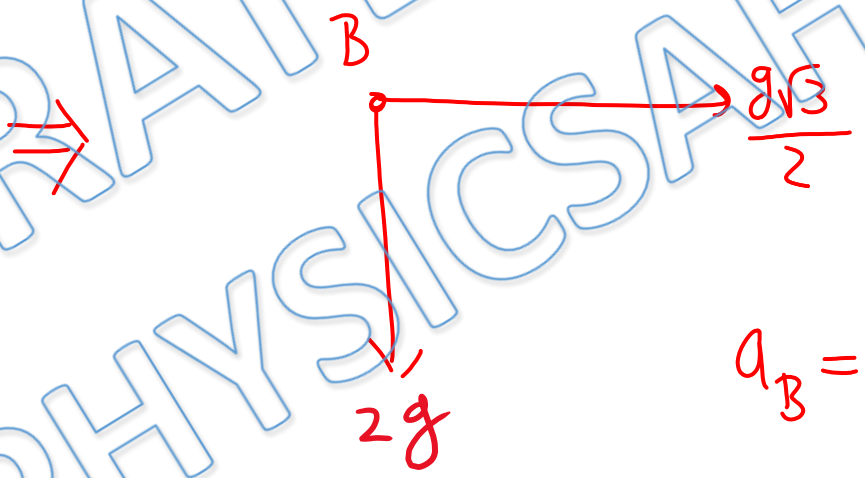
$a_1 = g/2$ — (II)

$\tau_{CM} = I_{CM}\alpha \Rightarrow \frac{mg}{2} \times \frac{l}{2} = \frac{ml^2}{12}\alpha \Rightarrow \alpha = 3g/l$

Ans. d



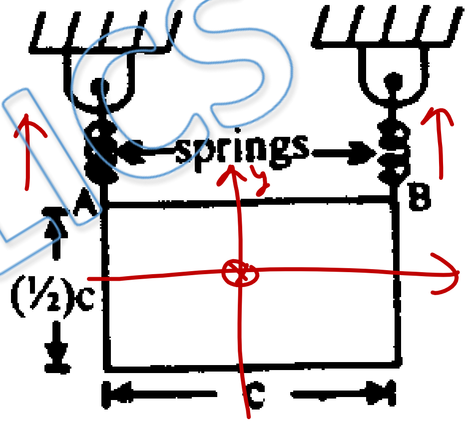




$$a_B = g\sqrt{\frac{3}{4} + 4}$$

$$= g\sqrt{\frac{19}{4}} = \frac{g}{2}\sqrt{19}$$

Q10) A uniform plate is hanging with the help of two strings as shown. Find angular acceleration of plate just after breaking connection of spring at B ?



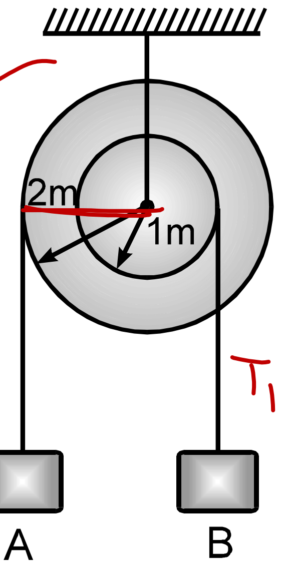
(a) g/5c

(b) 4g/5c

(c) 12g/5c

(d) g/c

Q11) In the pulley system shown, if radii of the bigger and smaller pulley are 2 m and 1 m respectively and the acceleration of block A is 5 m/s2 in the downward direction, then the acceleration of block B will be:



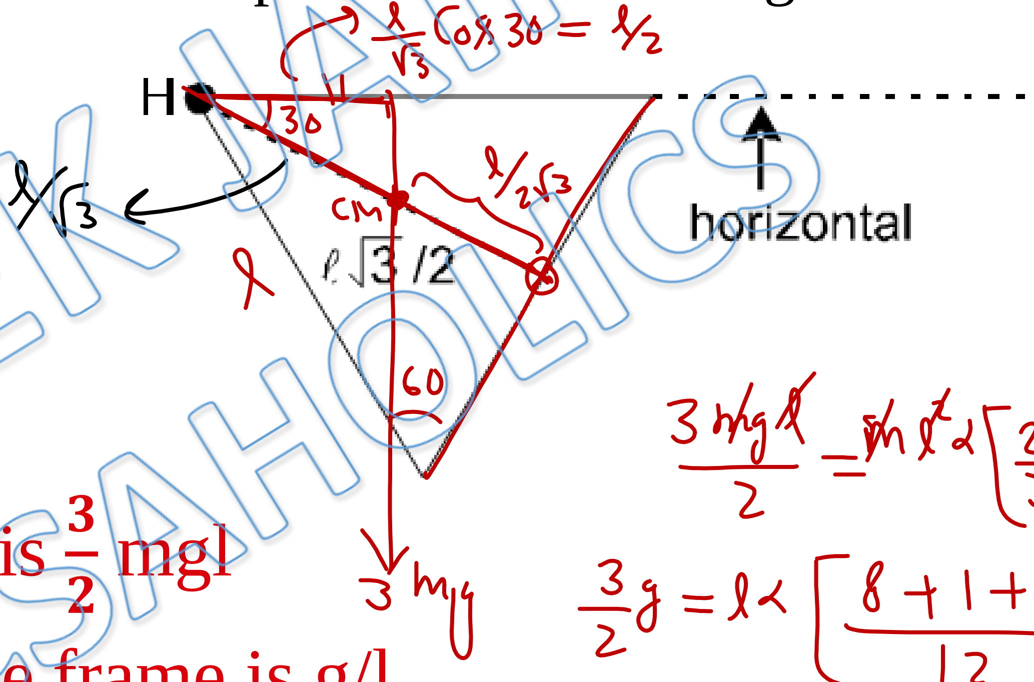
$\alpha = \frac{5}{2}$

$a_B = \alpha \times 1$

$= 5/2 \text{ m/sec}^2$

(a) 0 m/s^2 (b) 5 m/s^2 (c) 10 m/s^2 (d) 5/2 m/s^2

Q12) A rigid equilateral triangular frame made of three identical thin rods (mass = m & length = l) is free to rotate smoothly in vertical plane. Frame is hinged at one of its vertices H. Frame is released from rest from the position shown in figure then select correct alternative (s).



$\tau_H = 3mg\,\ell/2$

$\frac{3mg\ell}{2} = \left[\frac{m\ell^2}{3} + \frac{m\ell^2}{3} + \frac{m\ell^2}{12} + \frac{m3\ell^2}{4}\right]\alpha$

(a) Net initial torque about point H is $\frac{3}{2}$ mgl

(b) Initial angular acceleration of the frame is g/l

(c) Initial force of hinge on the frame is 3 mg

(d) Initial force of hinge on the frame is $\sqrt{3}$mg

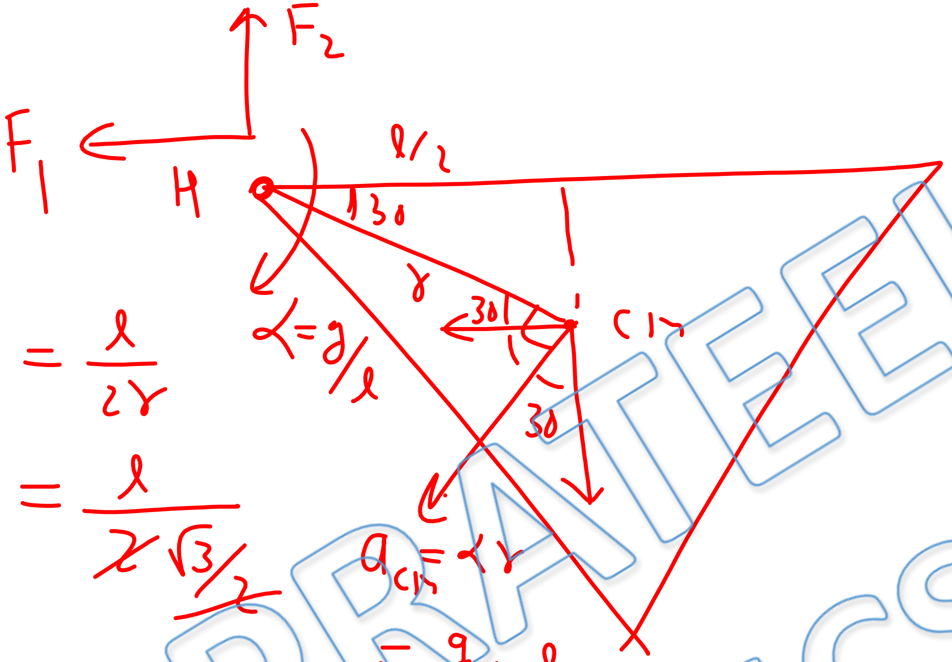
$\frac{3mg\ell}{2} = m\ell^2\alpha\left[\frac{2}{3} + \frac{1}{12} + \frac{3}{4}\right]$

$\frac{3}{2}g = \ell\alpha\left[\frac{8+1+9}{12}\right]$

$\frac{3g}{2} = \ell\alpha\left[\frac{3}{2}\right]$

$\alpha = g/\ell$

Ans. a, b, d



$\cos 30 = \frac{l}{2r}$

$r = \frac{l}{2\sqrt{3}/2}$

$\alpha = g/l$

$a_{cm} = \alpha r$

$= \frac{g}{l} \times \frac{l}{\sqrt{3}}$

$= \frac{g}{\sqrt{3}}$

$\frac{g}{\sqrt{3}} \sin 30 = \frac{g}{2\sqrt{3}}$

$\frac{g}{\sqrt{3}} \cos 30 = g/2$

$F_1 = 3mg/2\sqrt{3}$

$3mg - F_2 = 3m\, g/2$

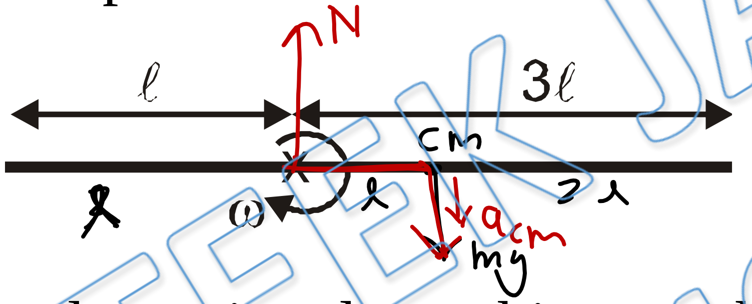
$F_2 = \frac{3}{2} mg$

$F = 3mg\sqrt{\frac{1}{12} + \frac{1}{4}}$

$= 3mg\sqrt{\frac{1+3}{12}} = \sqrt{3}\, mg$

Comprehension

A thin uniform rod having mass m and length 4l is free to rotate about horizontal axis passing through a point distant l from one of its end, as shown in figure. It is released, from the horizontal position as shown:



(Q13) What will be normal reaction due to hinge at the instant of release:

(a) mg

(b) $\frac{mg}{2}$

(c) $\frac{4mg}{7}$

(d) $\frac{\sqrt{2}mg}{7}$

Q14) Mark out the correct options :

(a) Angular acceleration about hinge at this instant is $\frac{3g}{7\ell}$

(b) Net torque about hinge at this instant will be $\frac{7}{5}mg\ell$

(c) Net torque about hinge at this instant will be mgl

(d) None of these

For Video Solution of this DPP, Click on below link

Video Solution on Website:- https://physicsaholics.com/home/courseDetails/81

Video Solution on YouTube:- https://youtu.be/5cTpO2GDiGs

Written Solution on Website:- https://physicsaholics.com/note/notesDetalis/18

Chalo Niklo