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PRAYAS

JEE 2025

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Lecture - 12

Physics

Laws Of Motion

By- Saleem Ahmed Sir

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Topics *to be covered*

1. Friction Questions Practice
2.
3.
4.

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Q

find min force required to move the block.

Ans ~~μmg~~

Soln

$F_{min} \Rightarrow (\cos\theta + \mu\sin\theta) \longrightarrow max$

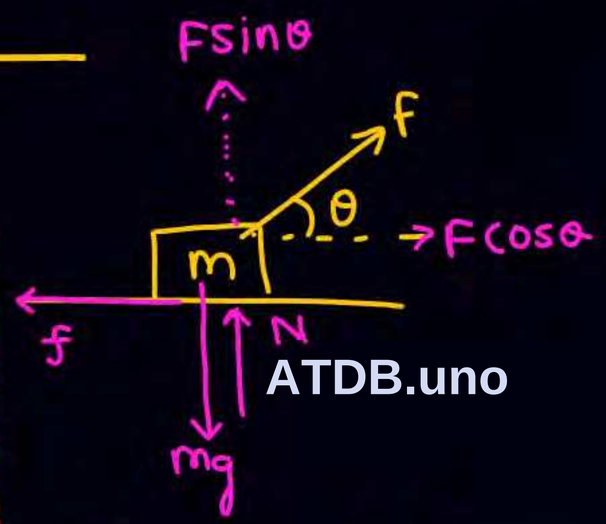
$\frac{d}{d\theta}(\quad) = 0$

$-\sin\theta + \mu\cos\theta = 0$

$\tan\theta = \mu$

$\theta = \tan^{-1}(\mu)$ पर

F_{min}



$N = mg - F\sin\theta$

$F\cos\theta > (f_s)_{max}$

$F\cos\theta = \mu_s N$ (limiting)

$F\cos\theta = \mu(mg - F\sin\theta)$

$F\cos\theta + \mu F\sin\theta = \mu mg$

$F(\cos\theta + \mu\sin\theta) = mg\mu$

$F = \frac{\mu mg}{\cos\theta + \mu\sin\theta}$

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$$F = \frac{\mu mg}{\cos\theta + \mu\sin\theta} \rightarrow \text{max}$$

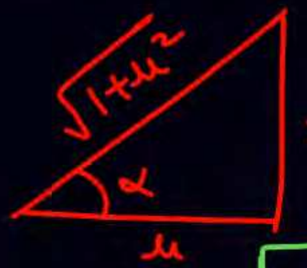
minimum

$$F = \frac{\mu mg}{\cos\theta + \mu\sin\theta}$$

$(a\cos\theta + b\sin\theta) \longrightarrow \text{max} = \sqrt{a^2+b^2}$

$$F = \frac{\mu mg}{\left(\frac{1}{\sqrt{1+\mu^2}}\cos\theta + \frac{\mu}{\sqrt{1+\mu^2}}\sin\theta\right)\sqrt{1+\mu^2}}$$

$$F_{min} = \frac{\mu mg}{\sqrt{1+\mu^2}}$$



F_{min} कब $\Rightarrow$ $\alpha+\theta = 90$

$\alpha = 90-\theta$

$\cot\alpha = \cot(90-\theta)$

$\cot\alpha = \tan\theta$

$\mu = \tan\theta$

$\theta = \tan^{-1}(\mu)$

$$\alpha = \tan^{-1}\left(\frac{1}{\mu}\right)$$

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$$F = \frac{\mu mg}{(\sin\alpha\cos\theta + \cos\alpha\sin\theta)\sqrt{1+\mu^2}}$$

$$F = \frac{\mu mg}{\sqrt{1+\mu^2}\,\underbrace{\sin(\alpha+\theta)}_{1\text{ (max)}}} \Rightarrow F_{min} = \frac{\mu mg}{\sqrt{1+\mu^2}}$$

min

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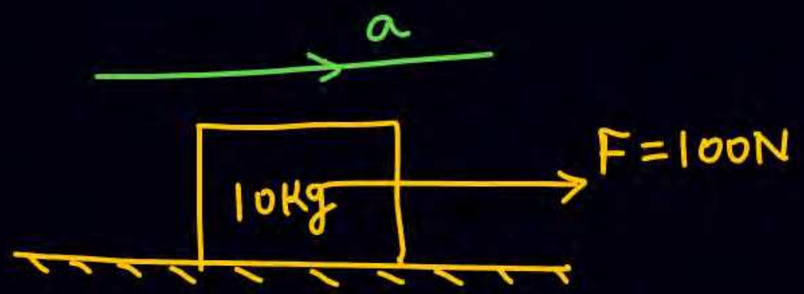

$\mu = .6$

① find a & Contact force with ground

$$(f_s)_{max} = \mu_s mg = .6 \times 100 = 60$$

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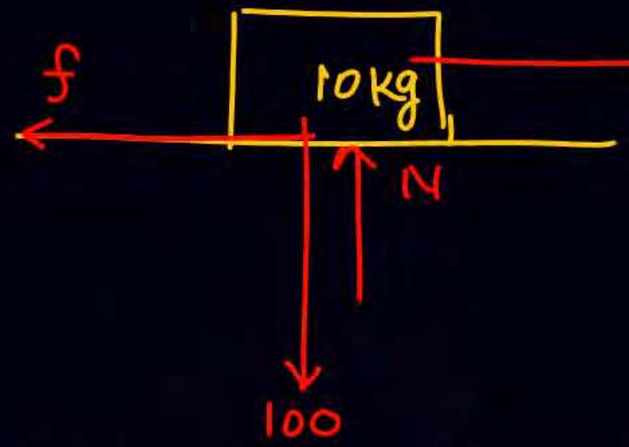
$$f_k = 60$$

$$a = \frac{100-60}{10} = 4$$



Contact force with ground $= \vec{N} + \vec{f}$

$$= \sqrt{N^2 + f^2} = \sqrt{(100)^2 + (60)^2}$$

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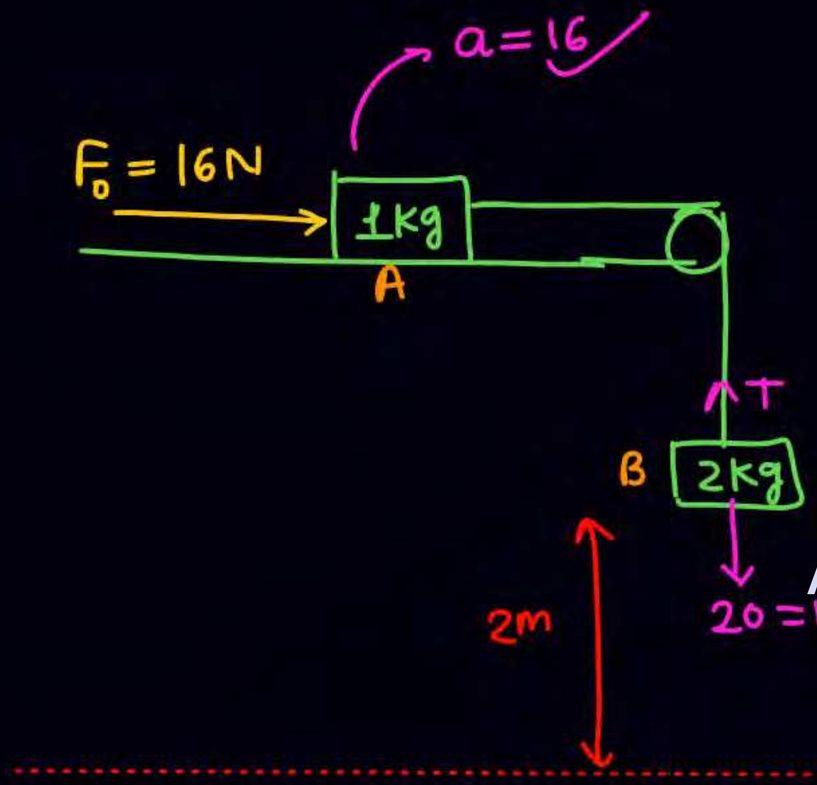
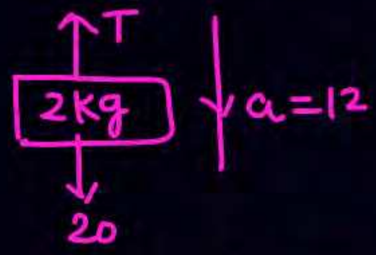


find when 2kg block will strike the ground.

$a = \frac{16+20}{1+2} = 12$ ($a_B = 12$ Not possible)

$T = 0$, $a_{2kg} = g$ नीचे



$2 = 0 + \frac{1}{2} \times g \times t^2$

$t = \sqrt{\frac{4}{10}}$

$20 - T = 2 \times 12$

$T = -4$ (not possible)

$T = 0$ (Correct)

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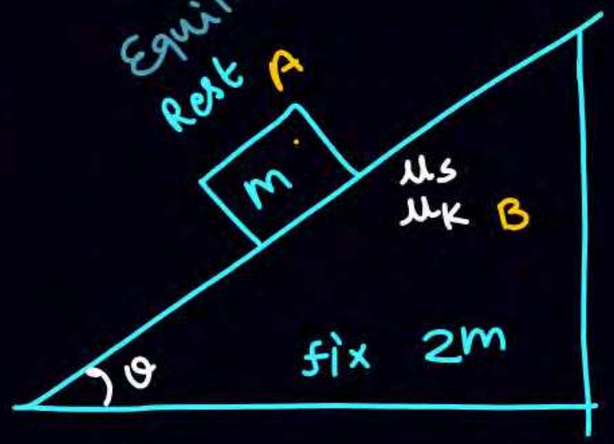

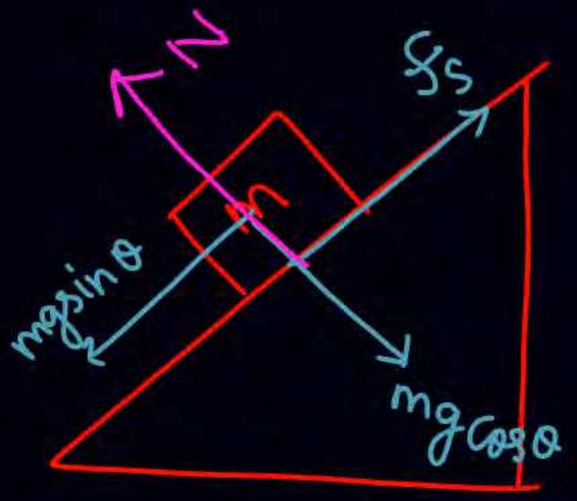

$mg\sin\theta = f_s$

find force applied by wedge 'B' on 'A'

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$$\sqrt{N^2 + f_s^2} = \sqrt{(mg\cos\theta)^2 + (mg\sin\theta)^2} = mg$$

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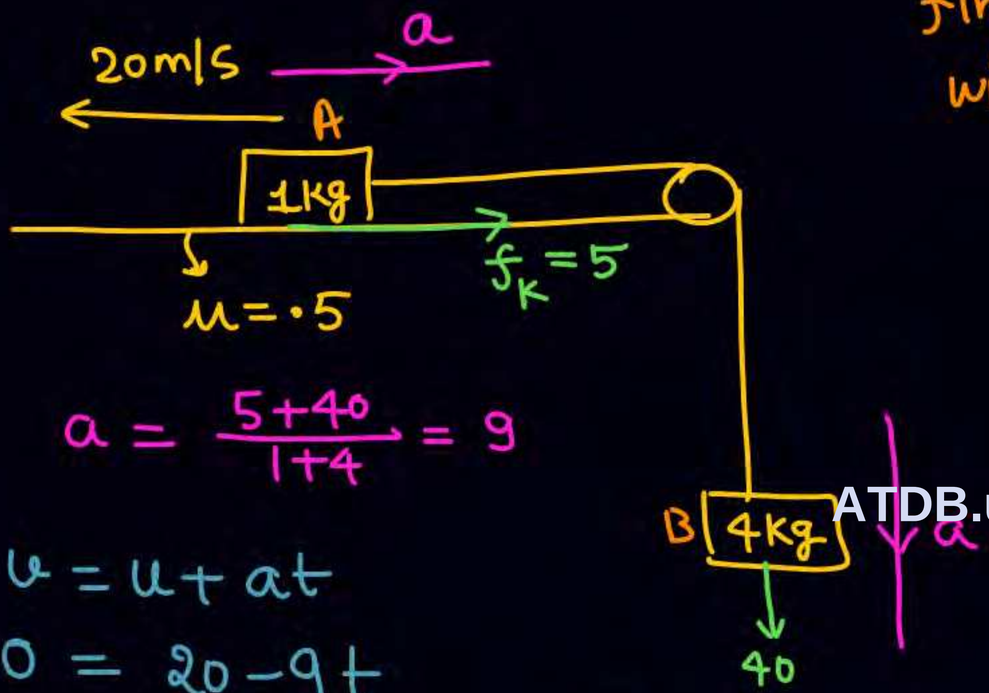

Find when and where 1kg block will come to at rest.

$$a = \frac{5+40}{1+4} = 9$$

$$v = u + at$$

$$0 = 20 - 9t$$

$$t = \frac{20}{9}$$

$$v^2 = u^2 + 2as$$

$$0 = (20)^2 - 2 \times 9 \times s'$$

$$s' = \frac{400}{18}$$

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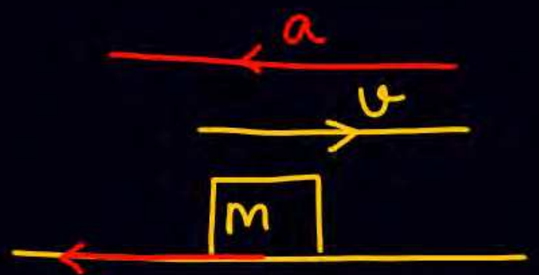
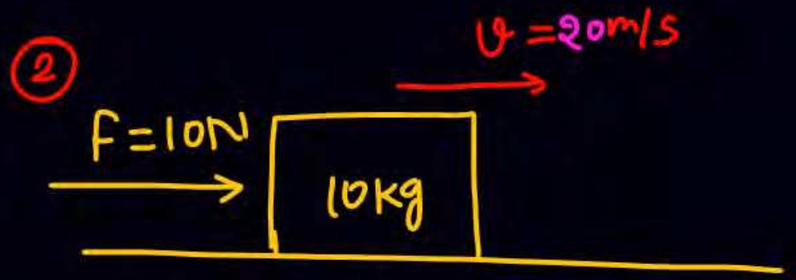


①

$f_k = \mu_k m g$

$a = \mu_k g$ पीछे



②

$\mu_s = .6$

$\mu_k = .5$

f ⟶ Kinetic लगेगा

$a = \frac{f - f}{m} = \frac{10 - 50}{10} = -4$

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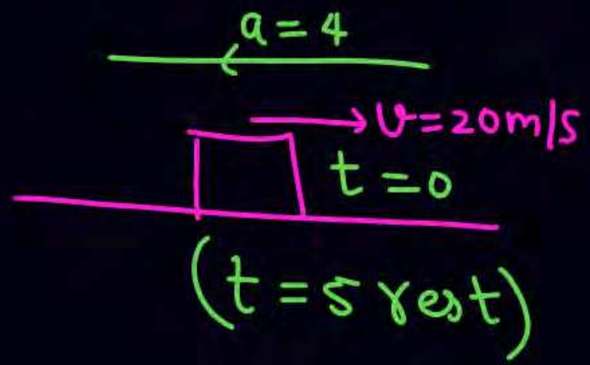

(t = 5 rest)

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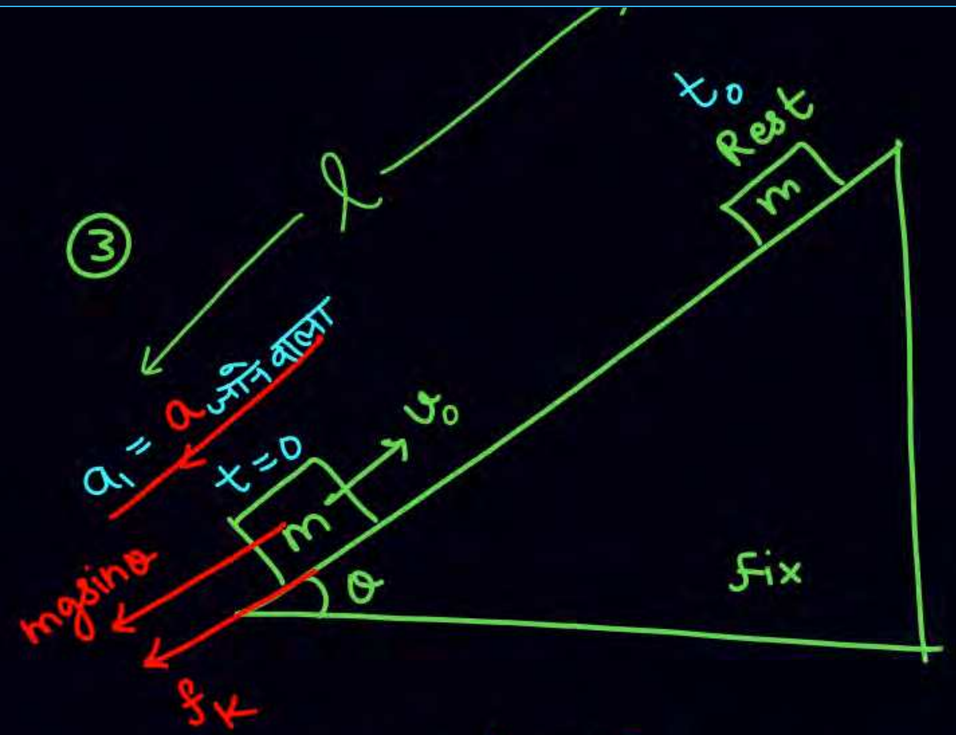

$$a_1 = a = \frac{mg\sin\theta + f_K}{m} = g\sin\theta + \mu_K g\cos\theta$$

$$0 = v_0 - a_1 t_0 \Rightarrow t_0 = \frac{v_0}{a_1}$$

$$0^2 = v_0^2 - 2a_1\ell \Rightarrow \ell = \frac{v_0^2}{2a_1}$$

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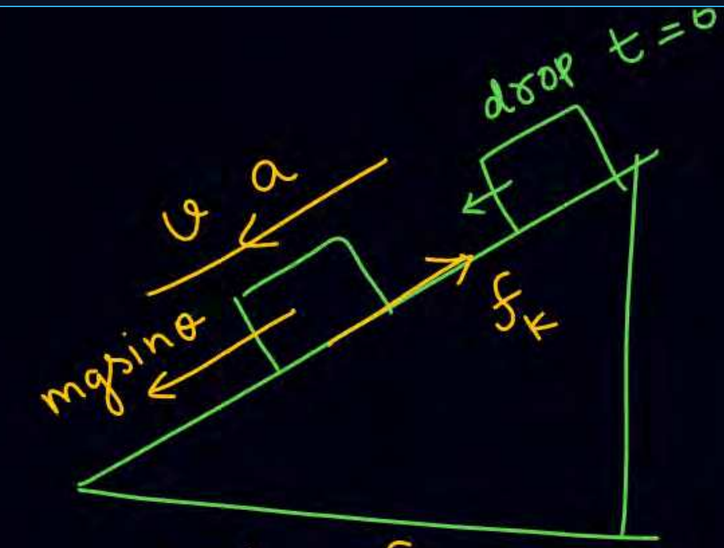

$$a = \frac{mg\sin\theta - f_K}{m} = g\sin\theta - \mu g\cos\theta$$

a आने वाला

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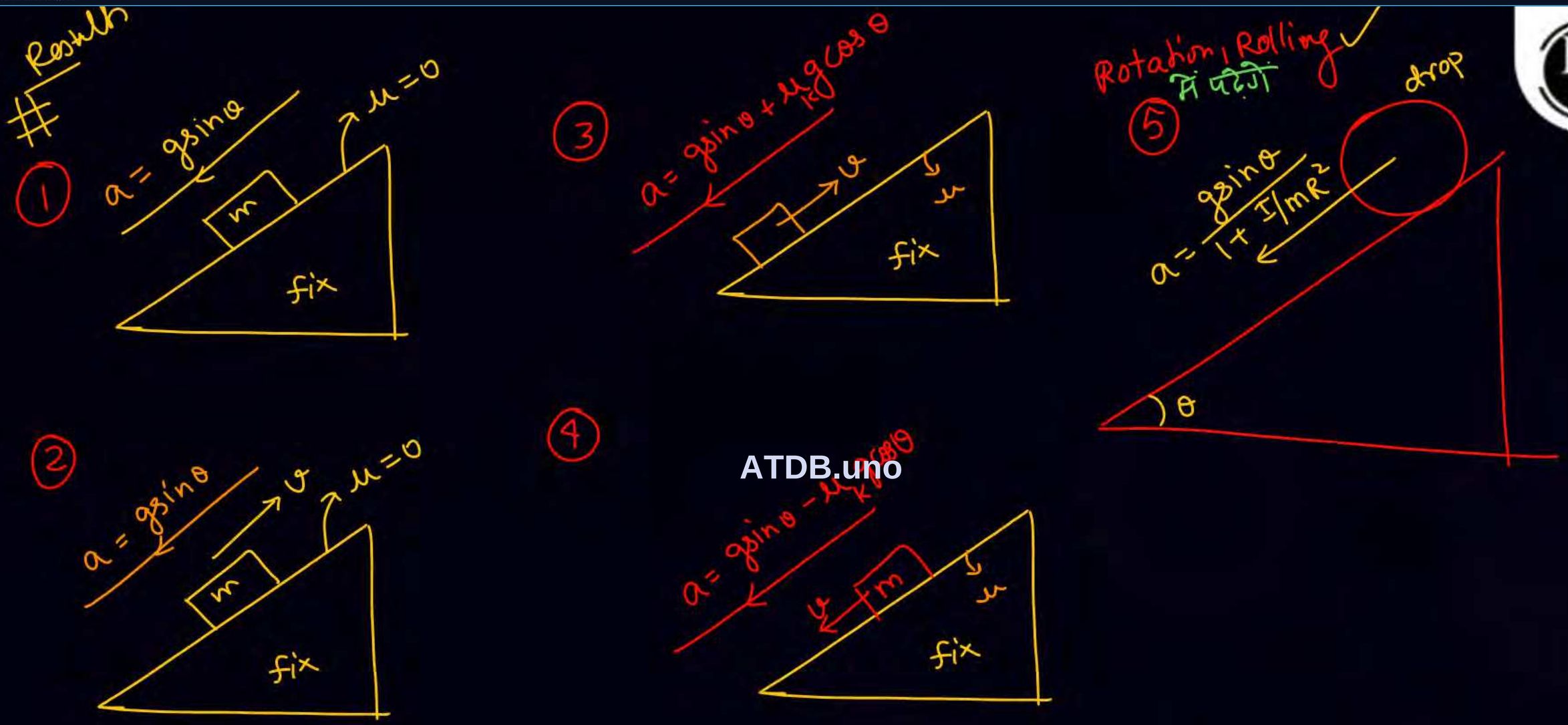
Result



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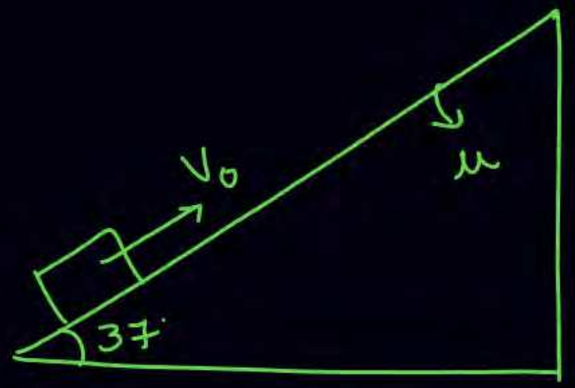
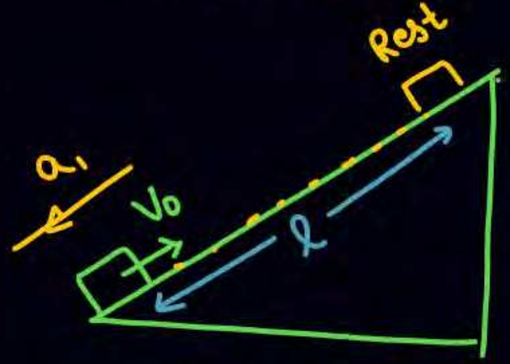


find μ so that time of ascent of body is two times less than time of decent.

Sol"

जाने वाला



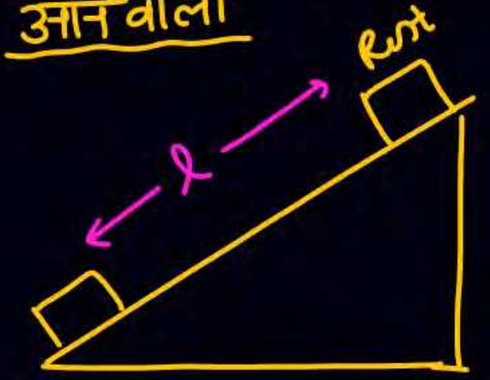
$$0 = V_0 - a_1 t_{\text{जाने}}$$

$$t_{\text{जाने}} = \frac{V_0}{a_1} = \frac{V_0}{g\sin\theta + \mu g\cos\theta}$$

$$0^2 = V_0^2 - 2a_1\ell$$

$$\ell = \frac{V_0^2}{2a_1}$$

आने वाला



$$\ell = 0 + \frac{1}{2}a_2 t^2_{\text{आने}}$$

$$t_{\text{आने}} = \sqrt{\frac{2\ell}{a_2}}$$

$$t_{\text{आने}} = \sqrt{\frac{2\ell}{g\sin\theta - \mu g\cos\theta}}$$

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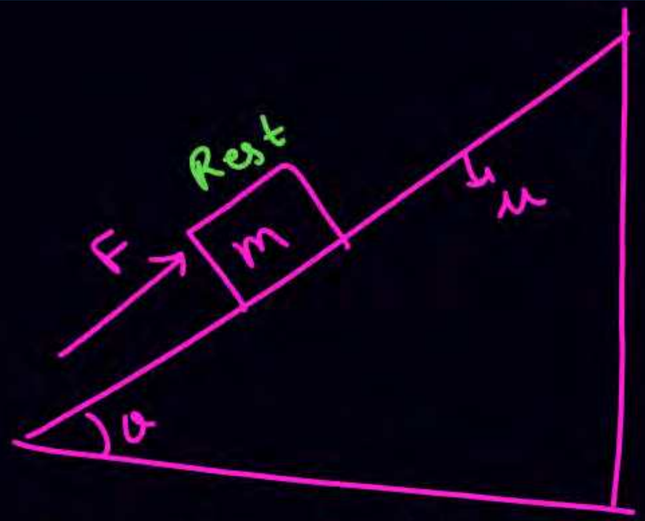
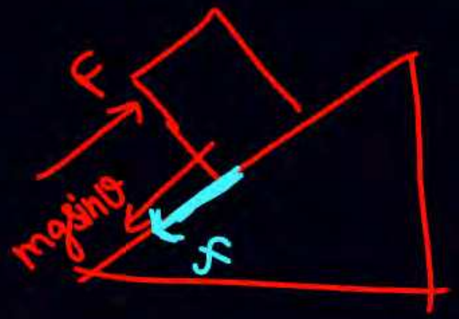
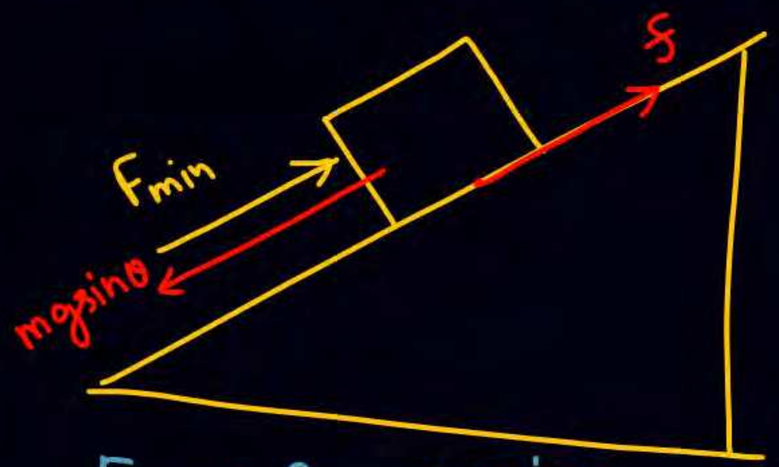


F_{min} to slide the block up along the inclined.

$$F_{min} = mg\sin\theta + \mu_s mg\cos\theta$$



F_{min} to prevent sliding down



$$F + f = mg\sin\theta$$

$$F = mg\sin\theta - f$$

$$\boxed{F_{min} = mg\sin\theta - \mu_s mg\cos\theta}$$

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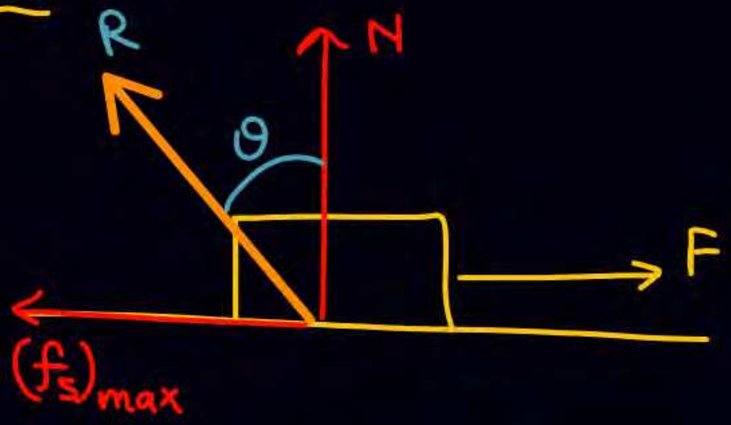
Angle of friction

$$\tan\theta = \frac{(f_s)_{max}}{N}$$

$$\tan\theta = \frac{\mu_s N}{N}$$

$$\tan\theta = \mu_s$$

$$\theta = \tan^{-1}(\mu_s)$$



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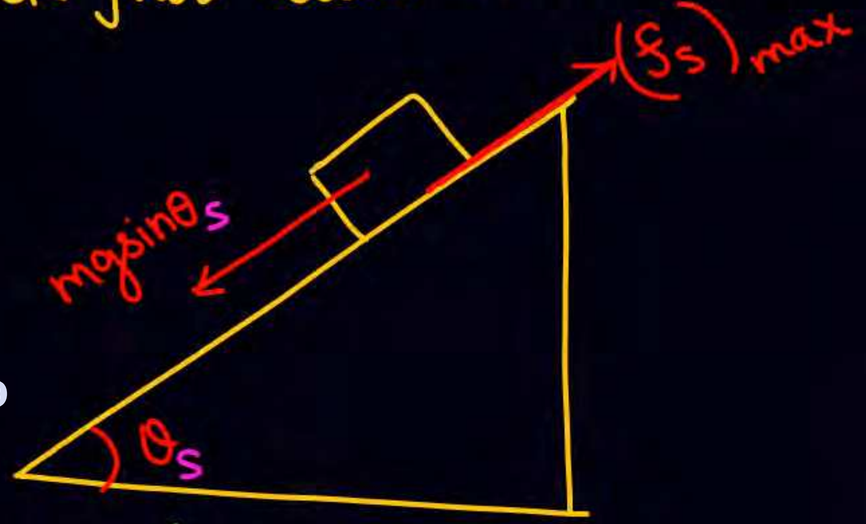
Angle of sliding / Angle of repose

to slide down

$\theta > \theta_s$

$\theta < \theta_s$ Rest

when block just about to slide down.



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$$mg\sin\theta_s = (f_s)_{max} = \mu_s mg\cos\theta_s$$

$$\tan\theta_s = \mu_s$$

$$\theta_s = \tan^{-1}(\mu_s)$$

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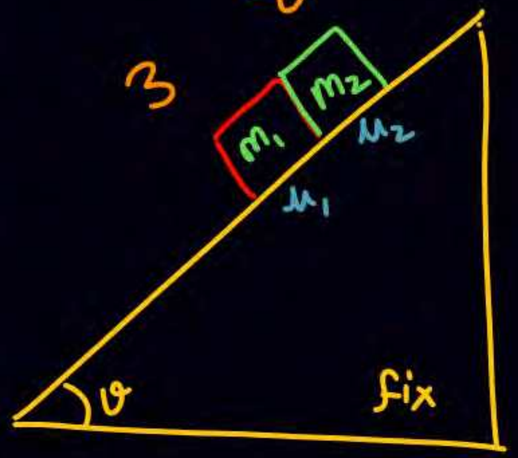
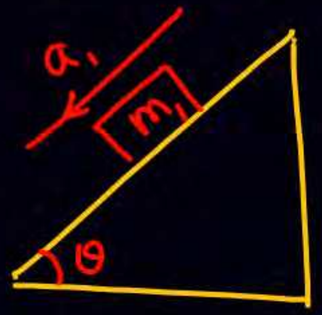
JEE

Q3

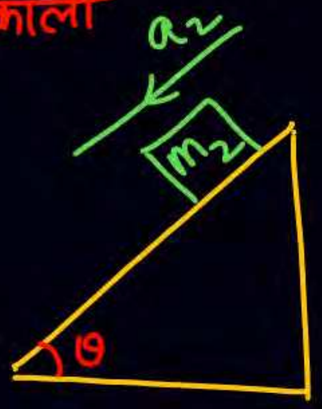


SKC

सबसे पहले individual acc निकालो



$a_1 = g\sin\theta - \mu_1 g\cos\theta$



$a_2 = g\sin\theta - \mu_2 g\cos\theta$

① if $a_1 \geq a_2 \Rightarrow a_{\text{आगे}} > a_{\text{पीछे}} \Rightarrow$ Separate ✓ $N_{\text{आपस}} = 0$

a_1 a_2 ≡ ✓

② $a_1 < a_2 \Rightarrow a_{\text{पीछे}} > a_{\text{आगे}}$

|||

Both will move with Common acc.

$$a = \frac{(m_1+m_2)g\sin\theta - f_1 - f_2}{m_1+m_2}$$

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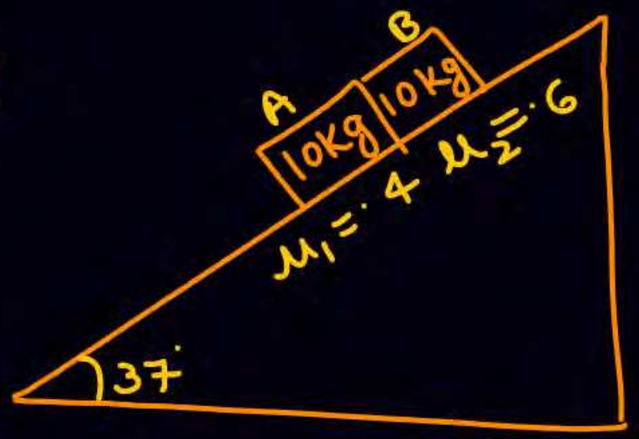

$(a_A)_{individual} = g\sin\theta - \mu g\cos\theta$

$= 6 - .4 \times 8$

$a_1 = 2.8$

$(a_B)_{individual} = 6 - .8 \times 6$

$a_2 = 1.2$

(a) they will separate ✓

$N = 0$

common

(b) gap b/w them after 5 sec

$S_{rel} = u_{rel}t + \frac{1}{2}a_{rel}t^2$

$S_{rel} = 0 + \frac{1}{2} \times (2.8 - 1.2) \times 5^2$

$gap = \frac{1}{2} \times 1.6 \times 25$

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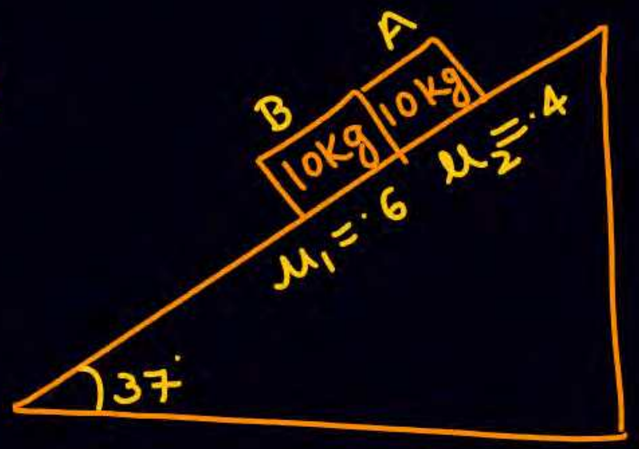


$a_{\text{आगे}} = a_1 = g\sin\theta - \mu g\cos\theta$

$= 6 - .6 \times 8$

$= 1.2$

$a_{\text{पीछे}} = a_2 = 6 - .4 \times 8$

$= 2.8$

$(a_{\text{आगे}} < a_{\text{पीछे}}) \equiv$ साथ-2

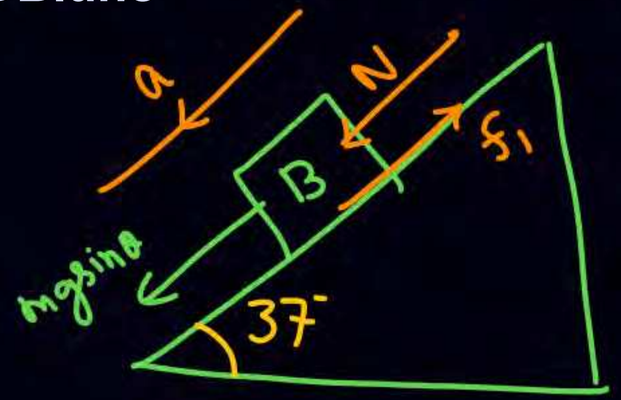
(b)

$$a = \frac{(m_1+m_2)g\sin\theta - f_1 - f_2}{m_1+m_2}$$

$$a = \frac{120 - .6\times 80 - .4\times 80}{20}$$

$a_{comm} = 6 - 2.4 - 1.6 = 2$

(c) find common normal b/w them



$60 + N - .6\times 80$

$= 10 \times 2$

$N = 20 + 48 - 60$

$N = 8$

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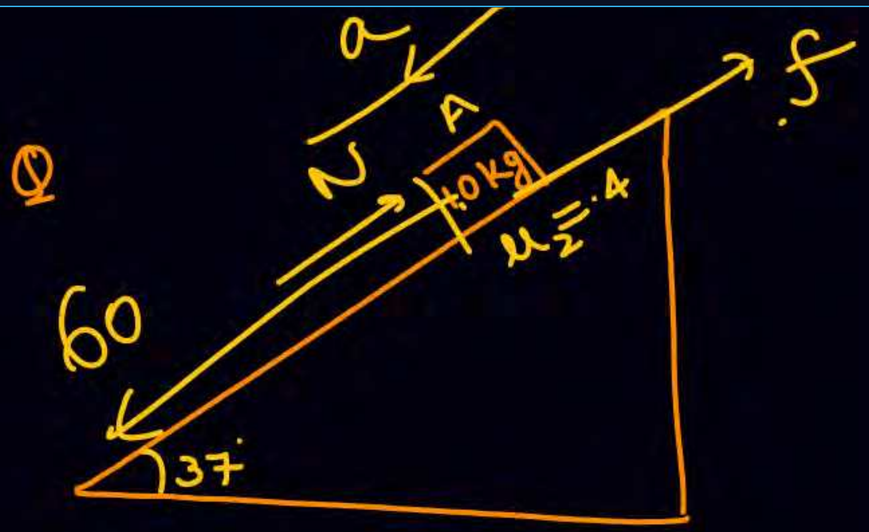


Q

$60 - N - f = ma$

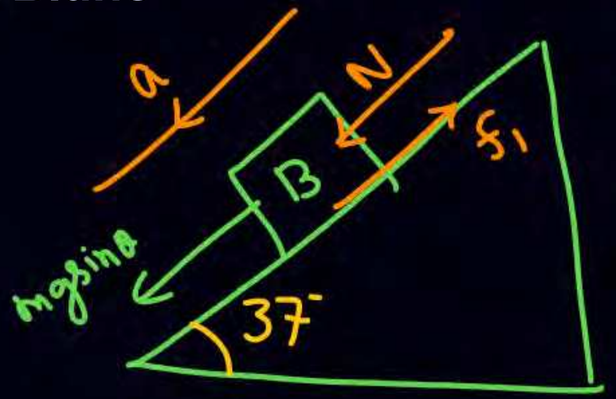
$60 - N - .4 \times 80 = 10 \times 2$

$60 - N - 32 = 20$

$60 - 32 - 20 = N$

$N = 8$

(c) find common normal b/w them



$60 + N - .6 \times 80 = 10 \times 2$

$N = 20 + 48 - 60$

$N = 8$

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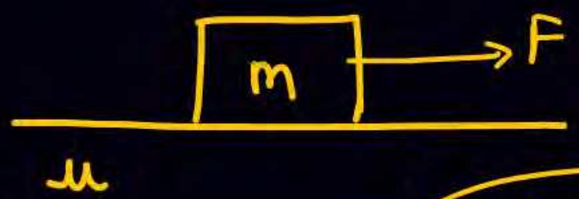
Q



find min horizontal force required to move the block.

$F > \mu mg$

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1. A block of mass $m_1 = 1$ kg another mass $m_2 = 2$kg, are placed together (see figure) on an inclined plane with angle of inclination θ. Various values of θ are given in List I. The coefficient of friction between the block m_1 and the plane is always zero. The coefficient of static and dynamic friction between the block m_2 and the plane are equal to $\mu = 0.3$. In List II expressions for the friction on block m_2 are given. Match the correct expression of the friction in List II with the angles given in List I, and choose the correct option. The acceleration due to gravity is denoted by g.

[**useful information :** $\tan(5.5°) \approx 0.1$; $\tan(11.5°) \approx 0.2$; $\tan(16.5°) \approx 0.3$]

एक आनत तल पर, जिसका आनत कोण θ है, द्रव्यमान $m_1 = 1$ kg तथा द्रव्यमान $m_2 = 2$kg के दो खण्ड आपस में सटाकर रखे गए हैं (जैसा चित्र में दिखाया गया है)। कोण θ के विभिन्न मान सूची-I में दिए गए हैं। खण्ड m_1 तथा आनत तल के बीच घर्षण गुणांक सदैव शून्य है। खण्ड m_2 तथा आनत तल के बीच स्थैतिक तथा गतिज घर्षण गुणांक $\mu = 0.3$ समान है। सूची-II में खण्ड m_2 पर लगने वाले घर्षण बल के व्यंजक दिए हैं। सूची-I को सूची-II से सुमेलित कीजिए तथा सूचियों के नीचे दिए गए कोड का प्रयोग करके सही उत्तर चुनिए। गुरुत्वीय त्वरण g से अंकित है।

[**आवश्यक आँकड़े :** $\tan(5.5°) \approx 0.1$; $\tan(11.5°) \approx 0.2$; $\tan(16.5°) \approx 0.3$] **[IIT-JEE-2014]**

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List–I/सूची–I

(P) $\theta = 5°$

(Q) $\theta = 10°$

(R) $\theta = 15°$

(S) $\theta = 20°$

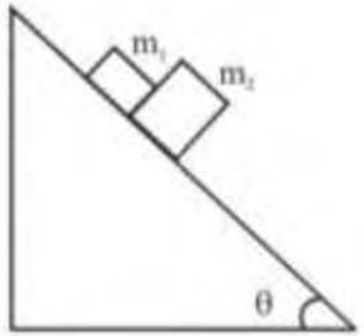
List–II/सूची–II

(1) $m_2 g \sin\theta$

(2) $(m_1 + m_2) g \sin\theta$

(3) $\mu m_2 g \cos\theta$

(4) $\mu(m_1 + m_2) g \cos\theta$



Code/कूट: :

(A) P-1, Q-1, R-1, S-3

(B) P-2. Q-2, R-2, S-3

(C) P-2,. Q-2, R-2, S-4

(D) P-2, Q-2, R-3, S-3

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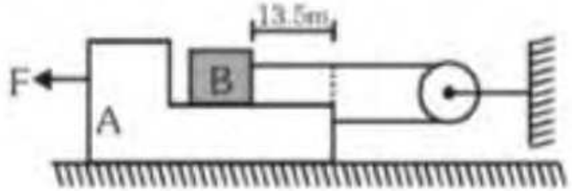
15. A 1 kg block 'B' rests as shown on a frictionless bracket 'A' of same mass. Constant force F = 3N starts to act at time t = 0, when the distance of block B from the end of bracket is 13.5m. Find time (in sec), when block B falls off the bracket.

1 kg द्रव्यमान का एक ब्लॉक B चित्रानुसार समान द्रव्यमान के एक घर्षण रहित ब्रेकेट A पर स्थित है। जब ब्लॉक B की ब्रेकेट के सिरे से दूरी 13.5m है तो समय t = 0 पर एक नियत बल F = 3N लगना प्रारम्भ होता है। वह समय (सेकण्ड में) ज्ञात कीजिये जब ब्लॉक B, A से गिर जायेगा।



Ans. 3

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39. An inclined plane is bent in such a way that the vertical cross-section is given by $y = \frac{x^2}{4}$ where y is in vertical and x in horizontal direction. If the upper surface of this curved plane is rough with coefficient of friction $\mu = 0.5$, the maximum height in cm at which a stationary block will not slip downward is _____ cm. **[JEE-Main-2021_Feb]**

एक आनत तल इस प्रकार झुका है कि उसकी ऊर्ध्वाधर अनुप्रस्थकाट $y = \frac{x^2}{4}$ द्वारा निरूपित की गयी है, यहाँ y ऊर्ध्वाधर तथा x क्षैतिज दिशा में हैं। यदि इस वक्रित तल का ऊपरी पृष्ठ रूक्ष है और इसका घर्षण गुणांक $\mu = 0.5$ है, तो वह अधिकतम ऊँचाई जिसमें कोई स्थिर गुटका नीचे की ओर नहीं फिसलेगा, _____ cm होगी। **[JEE-Main-2021_Feb]**

Ans. (25)

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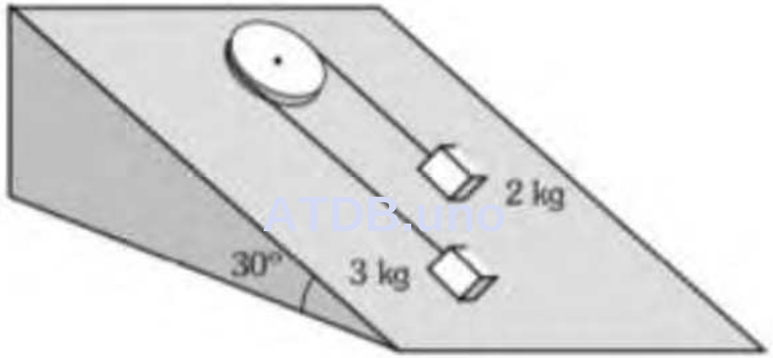
3. Two blocks of masses 2.0 kg and 3.0 kg are connected by light inextensible string. The string passes over an ideal pulley pivoted to a fixed axel on a smooth incline plane as shown in the figure. When the blocks are released, find magnitude of their accelerations.

दो ब्लॉक जिनका द्रव्यमान 2 kg और 3 kg है एक हल्की अवितान्य रस्सी द्वारा जुड़े हैं। रस्सी एक आदर्श घिरनी से गुजरती है, जो चित्रानुसार एक चिकने नत-तल पर स्थिर एक्सेल पर कीलकित है। जब ब्लॉक को छोड़ा जाता है, तो उनका त्वरण ज्ञात कीजिये।



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Ans. $\frac{g}{10} m/s^2$

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17. A thin rod of length 1 m is fixed in a vertical position inside a train, which is moving horizontally with constant acceleration 4 m/s^2. A bead can slide on the rod, and friction coefficient between them is 1/2. If the bead is released from rest at the top of the rod, find the time when it will reach at the bottom.[g = 10 m/s^2]

1m लम्बाई की एक पतली छड़ एक ट्रेन के अन्दर उर्ध्वाधर स्थिति में स्थिर है जो कि 4 m/s^2 के नियत त्वरण से क्षैतिज दिशा में गति कर रही है। एक मोती (bead) छड़ पर फिसल सकता है तथा उनके मध्य घर्षण गुणांक 0.5 है। यदि मोती को छड़ के शीर्ष से विराम अवस्था से छोड़ा जाता है तो वह समय ज्ञात कीजिये जब यह पेंदे पर पहुँचेगा (g=10 m/s^2)

Ans. 1/2 s

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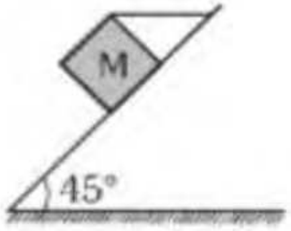
18. A block of mass 15 kg is resting on a rough inclined plane as shown in figure. The block is tied up by a horizontal string which has a tension of 50 N. Calculate the minimum coefficient of friction between the block and inclined plane.

15kg द्रव्यमान का एक ब्लॉक खुरदरे नत तल पर चित्रानुसार विराम में है। ब्लॉक एक क्षैतिज रस्सी से बँधा हुआ है जिसमें तनाव 50N है। ब्लॉक तथा नत तल के मध्य न्यूनतम घर्षण गुणांक ज्ञात कीजिए।



Ans. 0.5

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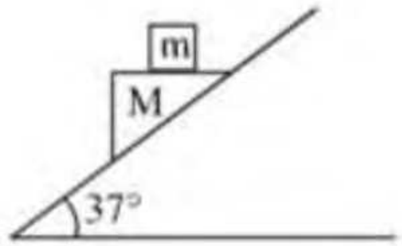
24. Block M slides down on frictionless incline as shown. Find the minimum friction coefficient so that m does not slide with respect to M.

चित्रानुसार ब्लॉक M एक घर्षणरहित नत तल पर नीचे की ओर फिसलता है। वह न्यूनतम घर्षण गुणांक ज्ञात कीजिये ताकि m, M के सापेक्ष इस पर गति ना करे?



Ans. 3/4

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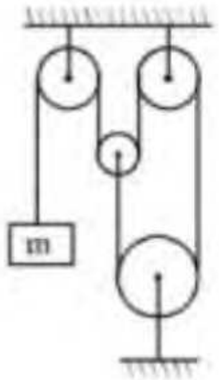
यदि रस्सी तथा सभी घिरनियां आदर्श हैं तो द्रव्यमान m का त्वरण होगा :-



(A) $\frac{g}{2}$ (B) 0 (C) g (D) dependent on m

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Ans. (C)

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pulley P does not offer any friction and coefficient of friction between pole and M is μ. The frictional force offered by the pole on M is

(A) Mg directed up

(B) μmg directed up

(C) $(M - m)g$ directed down

(D) μmg directed down

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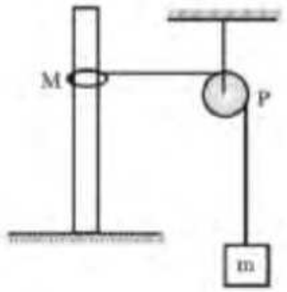

दर्शाये गये चित्र में M द्रव्यमान की वलय तथा m द्रव्यमान का ब्लॉक साम्यावस्था में है। डोरी हल्की है तथा घिरनी P कोई घर्षण उत्पन्न नहीं करती और M तथा खम्भे के मध्य घर्षण गुणांक का मान μ है। खम्भे द्वारा M पर आरोपित घर्षण बल है–

(A) Mg ऊपर की ओर

(B) μ mg ऊपर की ओर

(C) $(M - m)$ g नीचे की ओर

(D) μ mg नीचे की ओर

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60. In the arrangement of Fig. 1.9 the masses m_0, m_1, and m_2 of bodies are equal, the masses of the pulley and the threads are negligible, and there is no friction in the pulley. Find the acceleration w with which the body m_0 comes down, and the tension of the thread binding together the bodies m_1 and m_2, if the coefficient of friction between these bodies and the horizontal surface is equal to k. Consider possible cases.

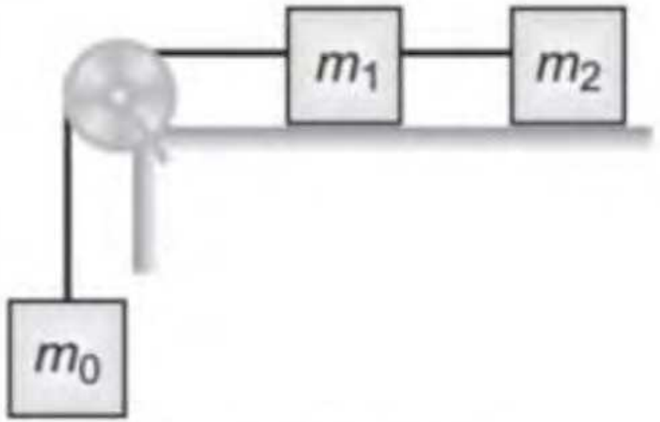

Fig. 1.9

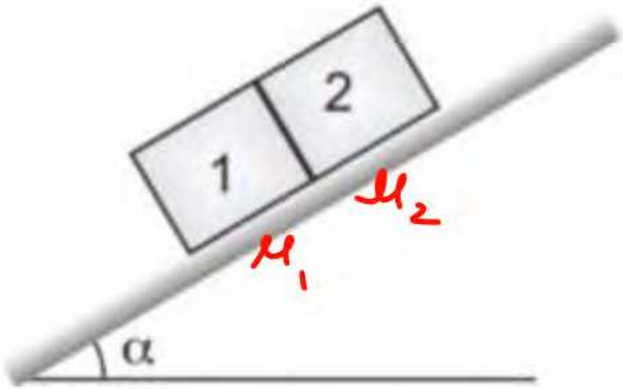

Fig. 1.10

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Ans : **60.** $\mathbf{w} = \dfrac{m_0 - k(m_1 + m_2)}{m_0 + m_1 + m_2}\mathbf{g}$. $T = \dfrac{(1 + k)m_0}{m_0 + m_1 + m_2} m_2 g$.

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61. Two touching bars 1 and 2 are placed on an inclined plane forming an angle α with the horizontal (Fig., 1.10). The masses of the bars are equal to m_1 and m_2, and the coefficients of friction between the inclined plane and these bars are equal to k_1 and k_2 respectively, with $k_1 > k_2$. Find:

(a) the force of interaction of the bars in the process of motion;

(b) the minimum value of the angle α at which the bars start sliding down.

$a_{cc} = a$
weight $= w$
Coff. of frict $= \mu$
Spring const $= k$

$a_{cc} \Rightarrow w$
Coff. of frict $= k$

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Ans :

61. (a) $F = \dfrac{(k_1 - k_2)\, m_1 m_2 g \cos\alpha}{m_1 + m_2}$; (b) $\tan\alpha_{\min} = \dfrac{k_1 m_1 + k_2 m_2}{m_1 + m_2}$.

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59. An aerostat of mass m starts coming down with a constant acceleration w. Determine the ballest mass to be dumped for the aerostat to reach the upward acceleration of the same magnitude. The air drag is to be neglected.

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Ans : **59.** $\Delta m = 2mw/(g + w)$.

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64. The inclined plane of Fig. 1.11 forms an angle $\alpha = 30^\circ$ with the horizontal. The mass ratio $m_2/m_1 = \eta = 2/3$. The coefficient of friction between the body m_1 and the inclined plane is equal to $k = 0.10$. The masses of the pulley and the threads are negligible. Find the magnitude and the direction of acceleration of the body m_2 when the formerly stationary system of masses starts moving.

$\frac{m_2}{m_1} = \frac{2}{3}$

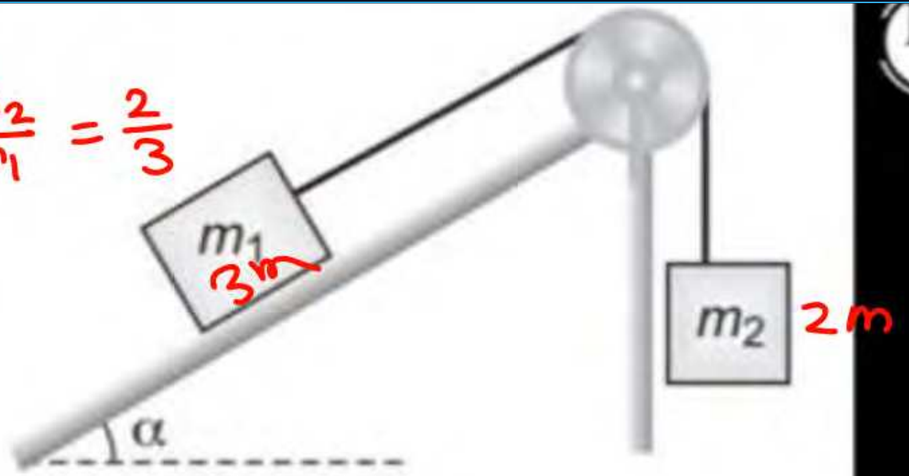

Fig. 1.11

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Ans : **64.** $w_2 = g(\eta - \sin\alpha - k\cos\alpha)/(\eta + 1) = 0.05\,g.$

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62. A small body was launched up an inclined plane set at an angle $\alpha = 15^\circ$ against the horizontal. Find the coefficient of friction, if the time of the ascent of the body is $\eta = 2.0$ times less than the time of its descent.

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Ans : **62.** $k = [(\eta^2 - 1)/(\eta^2 + 1)] \tan \alpha = 0.16.$

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68. At the moment $t = 0$ the force $F = at$ is applied to a small body of mass m resting on a smooth horizontal plane (a is a constant).
The permanent direction of this forms an angle α with the horizontal (Fig. 1.14). Find :

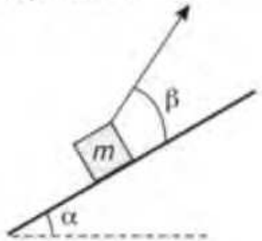

Fig. 1.13

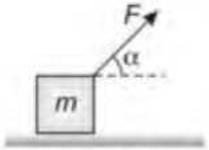

Fig. 1.14

(a) the velocity of the body at the moment of its breaking off the plane;
(b) the distance traversed by the body up to this moment.

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Ans : **68.** (a) $v = \dfrac{mg^2 \cos\alpha}{2a \sin^2\alpha}$; (b) $s = \dfrac{m^2 g^3 \cos\alpha}{6a^2 \sin^3\alpha}$.

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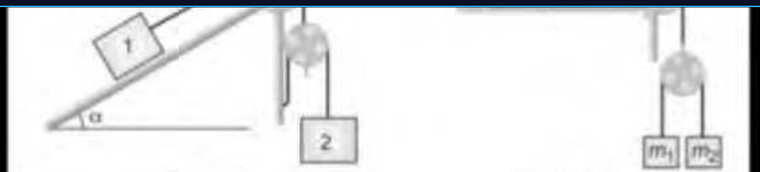

Fig. 1.15

Fig. 1.16

Ans : **72.** $w = 2g\,(2\eta - \sin\alpha)/(4\eta + 1)$.

73. In the arrangement shown in Fig. 1.16 the bodies have masses m_0, m_1, m_2, the friction is absent, the masses of the pulleys and the threads are negligible. Find the acceleration of the body m_1. Look into possible cases.

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Ans : **73.** $w_1 = \dfrac{4m_1m_2 + m_0(m_1 - m_2)}{4m_1m_2 + m_0(m_1 + m_2)}\,g.$

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72. Find the acceleration **w** of the body 2 in the arrangement shown in Fig. 1.15, if its mass is η times as great as the mass of bar 1 and the angle that the inclined plane forms with the horizontal is equal to α. The masses of the pulleys and the threads, as well as the friction, are assumed to be negligible. Look into possible cases.

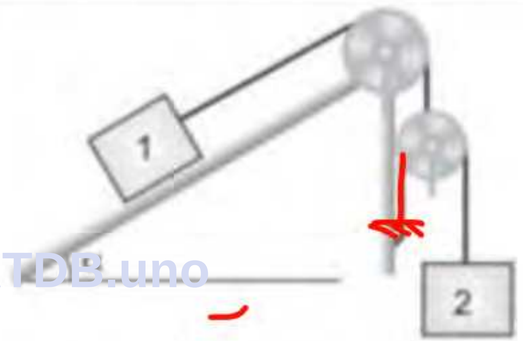

Fig. 1.15

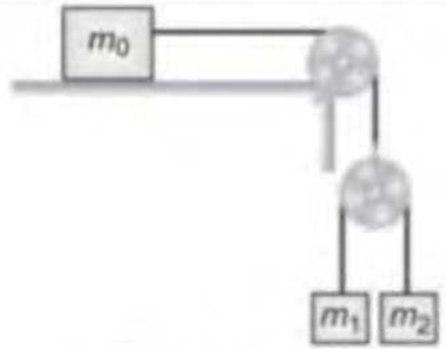

Fig. 1.16

Ans : **72.** $\mathbf{w} = 2g\,(2\eta - \sin\alpha)/(4\eta + 1)$.

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71. A pulley fixed to the ceiling of an elevator car carries a thread whose ends are attached to the loads of masses m_1 and m_2. The car starts going up with an acceleration $\mathbf{w}_0$. Assuming the masses of the pulley and the thread, as well as the friction, to be negligible find:

(a) the acceleration of the load m_1 relative to the elevator shaft and relative to the car;

(b) the force exerted by the pulley on the ceiling of the car.

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Ans :

71. (a) $\mathbf{w}_1 = \dfrac{(m_1 - m_2)\mathbf{g} + 2m_2\mathbf{w}_0}{m_1 + m_2}$, $\mathbf{w}_1' = \dfrac{m_1 - m_2}{m_1 + m_2}(\mathbf{g} - \mathbf{w}_0)$;

(b) $\mathbf{F} = \dfrac{4m_1m_2}{m_1 + m_2}(\mathbf{g} - \mathbf{w}_0)$.

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77. Find the accelerations of rod A and wedge B in the arrangement shown in Fig. 1.20 if the ratio of the mass of the wedge to that of the rod equals η, and the friction between all contact surfaces is negligible.

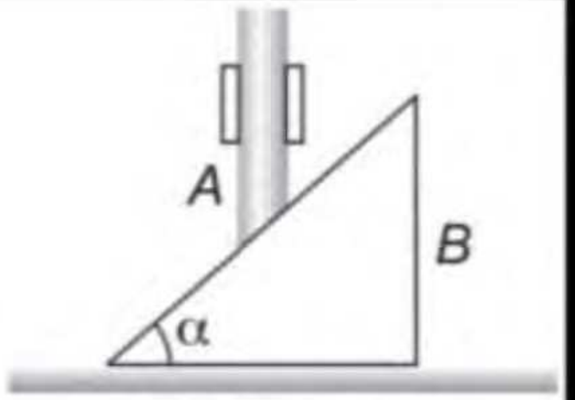

Fig. 1.20

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Ans : 77. $w_A = g/(1 + \eta \cot^2 \alpha)$, $w_B = g/(\tan \alpha + \eta \cot \alpha)$.

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76. In the arrangement shown in Fig. 1.19 the mass of body 1 is $\eta = 4.0$ times as great as that of body 2. The height $h = 20$ cm. The masses of the pulleys and the threads, as well as the friction, are negligible. At a certain moment body 2 is released and the arrangement set in motion. What is the maximum height that body 2 will go up to?

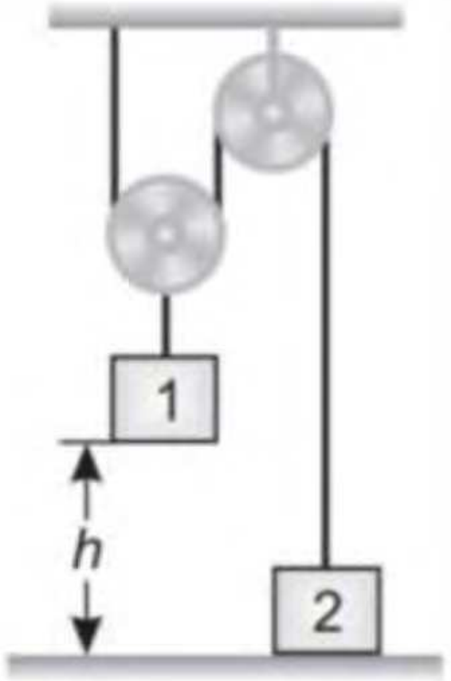

Fig. 1.19

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Ans : **76.** $H = 6h\eta/(\eta + 4) = 0.6$ m.

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82. In the arrangement shown in Fig. 1.24 the masses m of the bar and M of the wedge, as well as the wedge angle α, are known.

The masses of the pulley and the thread are negligible. The friction is absent. Find the acceleration of the wedge M.

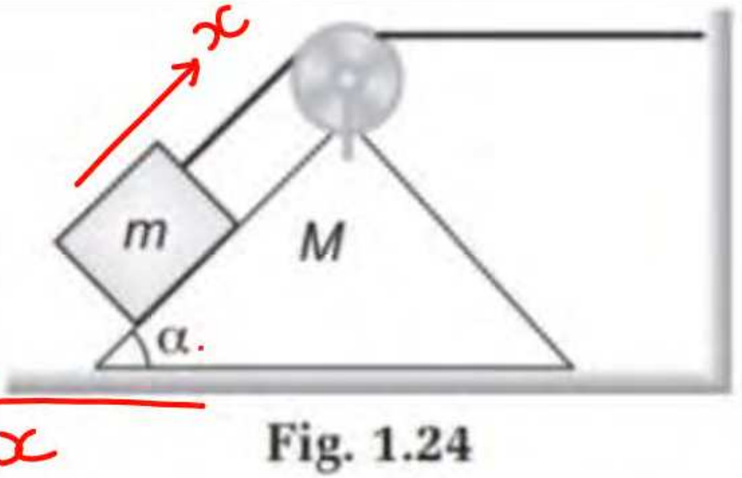

Fig. 1.24

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Ans : **82.** $w = \dfrac{mg \sin \alpha}{M + 2m(1 - \cos \alpha)}$.

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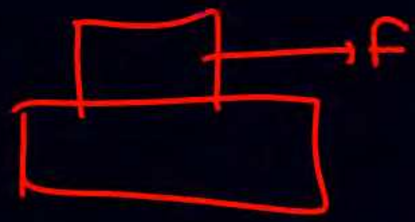
Reco

30-40min

1. two block problem



2. spring cutting

3. Ques Practice + Layman problem Ques.

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Homework

- Revise all notes & DPP
- HCV (most toy) ⇒ Friction page 98

20, 11, 12, 13, 18, (1-7), 10, 21, 29

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