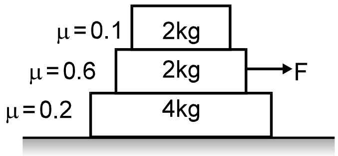
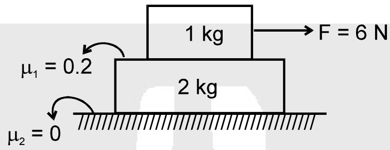
High Level Problems (HLP)

SUBJECTIVE QUESTIONS

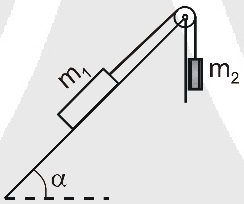
1.# In the situation shown in figure, for what value of minmum horizontal force F (in Newton), sliding between middle and lower block will start ? (Take g = 10 m/s^2)



2.# In the situation shown find the accelerations of the blocks. Also find the accelerations if the force is shifted from the upper block to the lower block.



3.# The inclined plane of Fig. forms an angle $\alpha = 30°$ 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 system of masses starts moving.

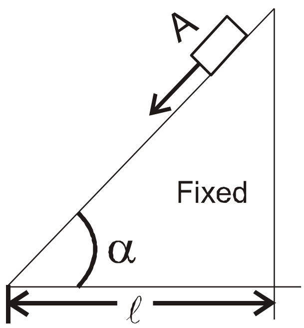


4. A small mass slides down an inclined plane of inclination θ with the horizontal. The co-efficient of friction is $\mu = \mu_0 x$ where x is the distance through which the mass slides down and μ_0, a constant. Then find

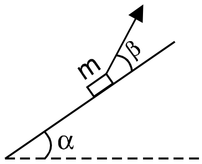
(a) Maximum speed of particle

(b) How much distance it will cover to get that maximum speed

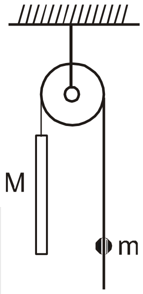
5.# A small body A starts sliding down from the top of a wedge (Fig.) whose base is equal to ℓ = 2.10 m. The coefficient of friction between the body and the wedge-surface is k = 0.140. At what value of the angle will the time of sliding be the least ? What will it be equal to ?



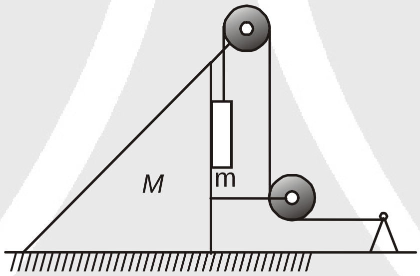
6.# A bar of mass m is pulled by means of a thread up an inclined plane forming an angle α with the horizontal (fig.). The coefficient of friction is equal to k. Find the angle β which the thread must form with the inclined plane for the tension of the thread to be minimum. What is it equal to ?



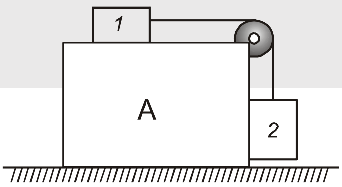
7.# In the arrangement shown in Fig. the mass of the rod M exceeds the mass m of the ball. The ball has an opening permitting it to slide along the thread with some friction. The mass of the pulley, mass of the string and the friction in its axle are negligible. At the initial moment the ball was located opposite the lower end of the rod. When set free, both bodies began moving with constant accelerations. Find the friction force between the ball and the thread if t seconds after the beginning of motion the ball got opposite the upper end of the rod. The rod length equals ℓ.



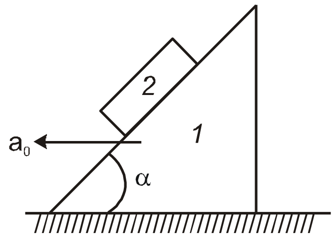
8.# In the arrangement shown in figure the masses of the wedge M and the body m are known. The appreciable friction exists only between the wedge and the body m, the friction coefficient being equal to k. The masses of the pulley and the thread are negligible. Find the acceleration of the body m relative to the horizontal surface on which the wedge Slides.



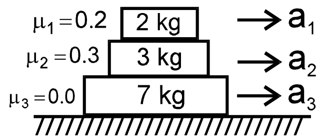
9.# What is the minimum acceleration with which bar A (figure) should be shifted horizontally to keep bodies 1 and 2 stationary relative to the bar? The masses of the bodies are equal and the coefficient of friction between the bar and the bodies is equal to k. The masses of the pulley and the threads are negligible, the friction in the pulley is absent.



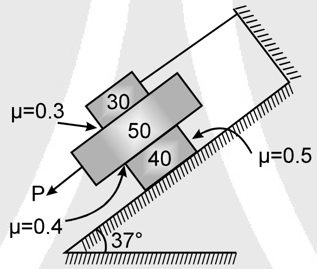
10.# Prism 1 with bar 2 of mass m placed on it gets a horizontal acceleration a_0 directed to the left (figure). At what maximum value of this acceleration will the bar be still stationary relative to the prism, if the coefficient of friction between them $k < \cot \alpha$?



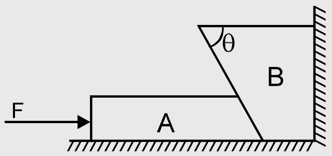
11. Find the accelerations a_1, a_2, a_3 of the three blocks shown in figure. If a horizontal force of 10N is applied on (i) 2 kg block, (ii) 3 kg block, (iii) 7 kg block. (Take g = 10 m/s^2)



12.# The three flat blocks as shown in the figure are positioned on the 37º incline and a force P parallel to the inclined plane is applied to the middle block. The upper block is prevented from moving by a wire which attaches it to the fixed support. The masses of three blocks in kg and coefficient of static friction for each of the three pairs of contact surfaces are shown in the figure. Determine the maximum value which force P may have before slipping take place anywhere. (g = 10 m/s^2)

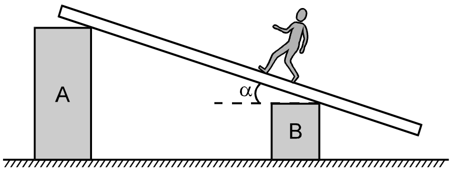


13.# In the figure shown, the coefficient of static friction between block B and the wall is 2/3 and the coefficient of kinetic friction between B and the wall is 1/3. Other contacts are smooth. Find the minimum force 'F' required to lift B, up. Now if the force applied on A is slightly increased than the calculated value of minimum force, then find the acceleration of B. Mass of A is 2m and the mass of B is m. Take tan θ = 3/4.

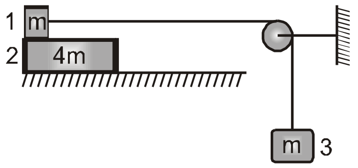


14. A plank of mass m_1 with a bar of mass m_2 placed on it lies on a smooth horizontal plane. A horizontal force growing with time t as F = kt (k is constant) is applied to the bar. Find how the accelerations of the plank a_1 and of the bar a_2 depend on t, if the coefficient of friction between the plank and the bar is equal to μ. Draw the approximate plots of these dependences.

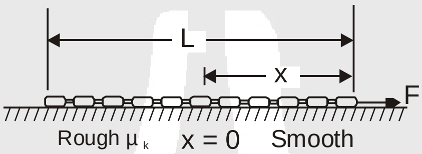
15.# A plank is held at an angle α to the horizontal (Fig.) on two fixed supports A and B. The plank can slide against the supports (without friction) because of its weight Mg. With what acceleration and in what direction, a man of mass m should move so that the plank does not move.


A
α
B

16.# In figure block 1 has one fourth mass and one fourth length of block 2 (mass 4m and length ℓ). No friction exists between block 2 and surface on which it rests. Coefficient of friction is μ_k between 1 & 2. The distance block 2 moves when only half of block 1 is still on block 2 is $\frac{n\mu_k \ell}{8(2-3\mu_k)}$. Then find value of n.



17.# A heavy chain with mass per unit length 'ρ' is pulled by the constant force F along a horizontal surface consisting of a smooth section and a rough section. The chain is initially at rest on the rough surface with x = 0. If the coefficient of kinetic friction between the chain and the rough surface is μ_k, then what is the velocity v (in m/s) of the chain when x = L, if the force F is greater than $\mu_k \rho g L$ in order to initiate the motion. If F = 21N, μ = 0.5, L = 1 m, ρ = 2 kg/m



HLP Answers

1. 30 N **2.** Upper block 4 m/s^2, lower block 1 m/s^2 ; Both blocks 2 m/s^2

3. $a_2 = g(\eta - \sin\alpha - k\cos\alpha) / (\eta + 1) = 0.05$ g. **4.** **(a)** $v_{max} = \sqrt{\frac{g\sin\theta\tan\theta}{\mu_0}}$ **(b)** $x = \frac{\tan\theta}{\mu_0}$

5. $\tan 2\alpha = (-1/k)$, $\alpha = 49^o$, t_{min} = 1.0s **6.** $\tan\beta = k$; $T_{min} = mg(\sin\alpha + k\cos\alpha)/\sqrt{1+k^2}$.

7. $F_{fr} = 2mM\ell/(M-m)t^2$ **8.** $a = g/\sqrt{2}\ (2 + k + M/m)$ **9.** $w_{min} = g(1-k)/(1+k)$

10. $w_{max} = g(1 + k\cot\alpha)/(\cot\alpha - k)$

11. (i) $a_1 = 3$ m/s^2, $a_2 = a_3 = 0.4$ m/s^2 , (ii) $a_1 = a_2 = a_3 = \frac{5}{6}$ m/s^2 , (iii) same as (b)

12. P = 12 N **13.** (i) $F_{min} = \frac{3}{2}mg$ (ii) $b = \frac{3g}{22}$

14. When $t \le t_0$, the accelerations $a_1 = a_2 = kt/(m_1 + m_2)$; when $t \ge t_0$
$a_1 = \mu g m_2 / m_1$, $a_2 = (kt - \mu m_2 g)/m_2$. Here $t_0 = \frac{\mu g(m_1+m_2)}{k} \times \frac{m_2}{m_1}$

15. $g\sin\alpha\left(1+\frac{M}{m}\right)$ down the incline **16.** 7 **17.** 4