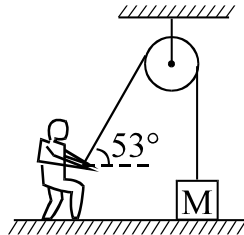


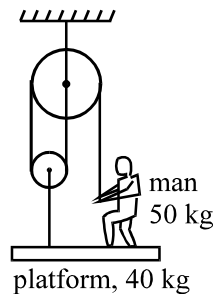
Laws of motion

Objective : Further problems or those seeking academic amusement and adventure

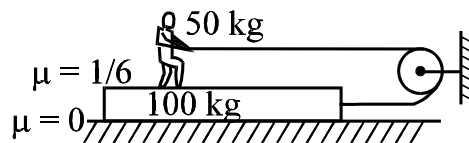
1. A man of mass 63 kg is pulling a mass M by an inextensible light rope passing through a smooth and massless pulley as shown in figure. The coefficient of friction between the man and the ground is $\mu = 3/5$. Find the maximum value of M that can be pulled by the man without slipping on the ground.



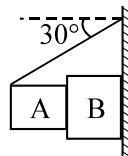
2. What force must man exert on rope to keep platform in equilibrium?



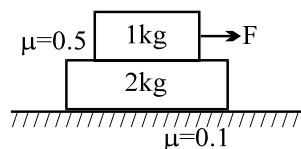
3. A man of mass 50 kg is pulling on a plank of mass 100 kg kept on a smooth floor as shown with force of 100 N. If both man & plank move together, find force of friction acting on man.



4. Two blocks A and B of mass m 10 kg and 20 kg respectively are placed as shown in figure. Coefficient of friction between all the surfaces is 0.2. Then find initial tension in string and initial acceleration of block B. ($g = 10 \text{ m/s}^2$)

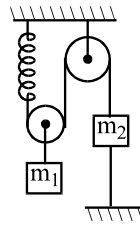


5. What should be minimum value of F so that 2 kg slides on ground but 1 kg does not slide on it? [$g = 10 \text{ m/sec}^2$]

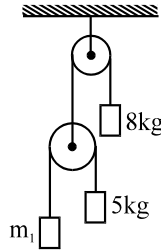


Laws of motion

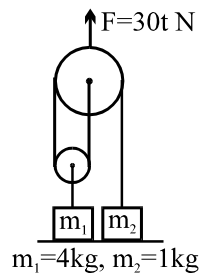
6. In figure shown, pulleys are ideal $m_1 > 2m_2$. Initially the system is in equilibrium and string connecting m_2 to rigid support below is cut. Find the initial acceleration of m_2 ?



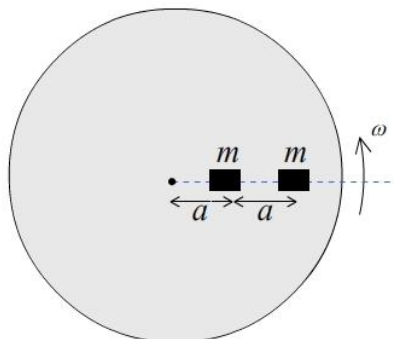
7. At what value of m_1 will 8 kg mass be at rest.



8. Force F is applied on upper pulley. If $F = 30t$ where t is time in second. Find the time when m_1 loses contact with floor.

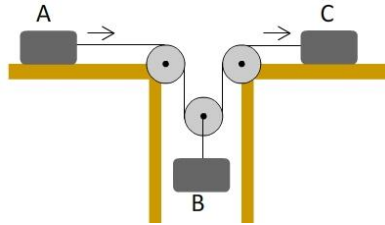


9. A block of mass 1 kg is horizontally thrown with a velocity of 10 m/s on a stationary long plank of mass 2 kg whose surface has a $\mu = 0.5$. Plank rests on frictionless surface. Find the time when m_1 comes to rest w.r.t. plank.
10. Two particles, each of mass m , are attached to each other through a small string (assumed to be inextensible and of negligible mass). They are placed on a rough horizontal circular table as shown in the figure. If the table rotates with uniform angular velocity ω and the bodies remain stationary w.r.t. the table then the minimum coefficient of friction between the bodies and the table is _____.

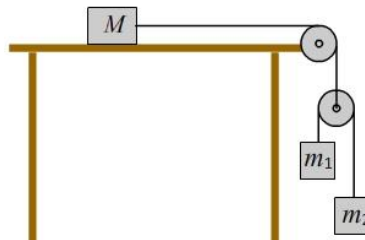


Laws of motion

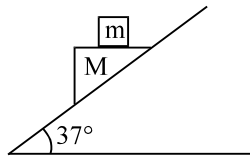
11. In the figure given below, blocks A and C start from rest and move towards right with accelerations given by $a_A = 12t \text{ ms}^{-2}$ and $a_C = 3\text{ms}^{-2}$ respectively. The instant of time when block B comes to rest is _____ .



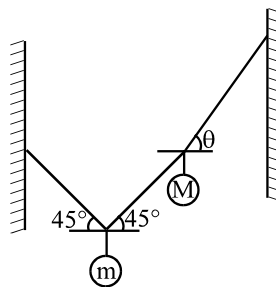
12. In the arrangement given below m_1 is of mass 1kg and m_2 is of mass 2kg. Find the value of M so that m_1 moves with uniform velocity. (all pulleys may be assumed to be of negligible mass and friction may be neglected)



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

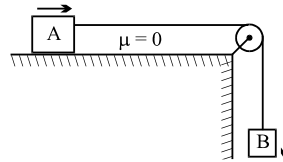


14. Two masses m and M are attached to the strings as shown in the figure. If the system is in equilibrium, then

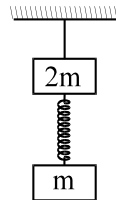


15. Both the blocks shown here are of mass m and are moving with constant velocity in direction shown in a resistive medium which exerts equal constant force on both blocks in direction opposite to the velocity. The tension in the string connecting both of them will be : (Neglect friction)

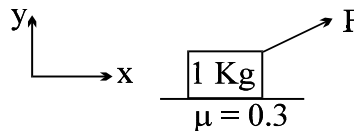
Laws of motion



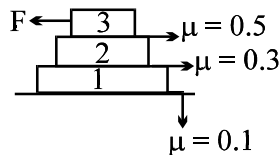
16. Two blocks are connected by a spring. The combination is suspended, at rest, from a string attached to the ceiling, as shown in the figure. The string breaks suddenly. Immediately after the string breaks, what is the initial downward acceleration of the upper block of mass $2m$?



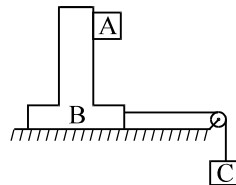
17. A body is placed on a rough inclined plane of inclination θ . As the angle θ is increased from 0° to 90° the contact force between the block and the plane
- (A) remains constant
 (B) first remains constant then decreases
 (C) first decreases then increases
 (D) first increases then decreases
18. A force acts on block shown. The force of friction acting on the block is



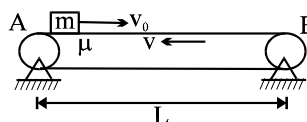
19. If force F is increasing with time and at $t = 0$, $F = 0$ where will slipping first start?



20. In the arrangement shown in the figure, mass of the block B and A is $2m$ and m respectively. Surface between B and floor is smooth. The block B is connected to the block C by means of a string pulley system. If the whole system is released, then find the minimum value of mass of block C so that block A remains stationary w.r.t. B. Coefficient of friction between A and B is μ .

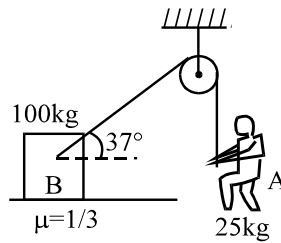


21. With what minimum velocity should block be projected from left end A towards end B such that it reaches the other end B of conveyer belt moving with constant velocity v . Friction coefficient between block and belt is μ .

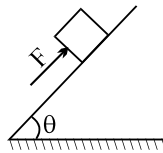


Laws of motion

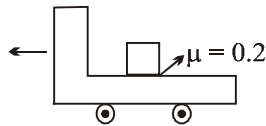
22. Block B of mass 100 kg rests on a rough surface of friction coefficient $\mu = 1/3$. A rope is tied to block B as shown in figure. The maximum acceleration with which boy A of 25 kg can climb on rope without making block move is _____



23. A block placed on a rough inclined plane of inclination ($\theta = 30^\circ$) can just be pushed upwards by applying a force F as shown. If the angle of inclination of the inclined plane is increased to ($\theta = 60^\circ$), the same block can just be prevented from sliding down by application of a force of same magnitude. The coefficient of friction between the block and the inclined plane is

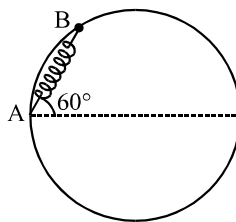


24. A truck starting from rest moves with an acceleration of 5 ms^{-2} for 1 second and then moves with constant velocity. The graph of velocity w.r.t ground as a function of time for block in truck is (Assume that block does not fall off the truck)



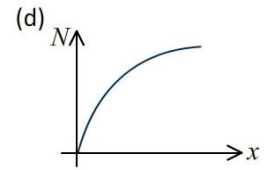
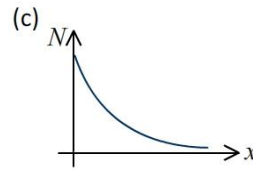
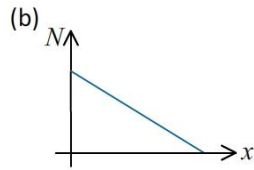
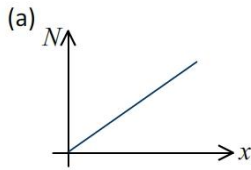
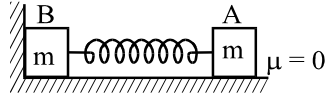
25. A particle is moving along the circle $x^2 + y^2 = a^2$ in anti clock wise direction. The $x - y$ plane is a rough horizontal stationary surface. At the point ($a \cos\theta, a \sin\theta$), the unit vector in the direction of friction on the particle is given by _____

26. A smooth ring of radius R is fixed in the vertical plane. A spring of spring constant $k = \frac{(\sqrt{3}+1)mg}{R}$ and natural length $\sqrt{3}R$ is fixed to the ring and a bead of mass m is connected to the other free end of the spring as shown in the figure. Normal reaction of the ring, at the instant the bead is released is _____

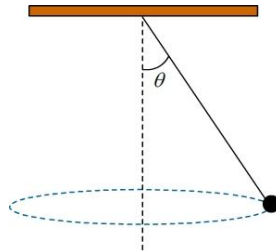


27. In the figure given below, block A is pushed towards the wall by a certain distance and released. Normal reaction of the wall on B, as a function of compression in the spring is given by

Laws of motion



28. A string of length 1m is fixed at one end and a body of mass 100 g is connected at the other end. The body rotates with an angular speed of $2/\pi$ revolutions per second about the vertical. If the tension in the string is $n/5$, find the value of n .



29. A bullet of mass m strikes an obstruction and deviates off at 60° to its original direction. If its speed is also changes from u to v , then the magnitude of impulse acting on the bullet is ____
30. A freight car is moving on smooth horizontal track without any external force. Rain is falling with a velocity $u\text{ ms}^{-1}$ at an angle θ with the vertical. Rain drops are collected in the car at a rate of $\mu\text{ kg/s}$. If initial mass of the car is m_0 and its velocity is v_0 then its velocity at time t is ____

Answers

1. 35 kg
2. 300 N
3. $100/3$ N towards LHS
4. 306 N, 4.7 ms^{-2}
5. 3N
6. $\frac{(m_1 - 2m_2)}{2m_2}g$
7. $10/3$ kg
8. 2 s
9. $4/3$ s
10. $3\omega^2 a/2g$
11. 0.5 s
12. 8 kg
13. $3/4$
14. $\tan(\theta) = 1 + \frac{2M}{m}$
15. $Mg/2$
16. $3g/2$

Laws of motion

17. First remains constant and then increases

18. $-\hat{i}$

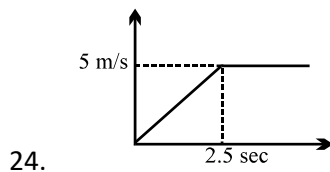
19. Between 1 kg and ground

20. $\frac{3m}{\mu - 1}$

21. $\sqrt{2\mu gL}$

22. $g/3$

23. $\frac{\sqrt{3} - 1}{\sqrt{3} + 1}$



25. $\sin(\theta)\hat{i} - \cos(\theta)\hat{j}$

26. $mg\left(1 - \frac{\sqrt{3}}{2}\right)$

27. Graph (b)

28. $n = 8$

29. $m\sqrt{u^2 - uv + v^2}$

30. $v = u \sin(\theta) \left(\frac{\mu t}{m_o + \mu t} \right) + \left(\frac{m_o v_o}{m_o + \mu t} \right)$

