EXERCISE-1

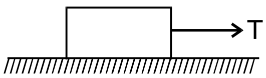
OBJECTIVE PROBLEMS

1. A force of 98 N is require to just start moving a body of mass 100 kg over ice. The coefficient of static friction is :
(A) 0.6 (B) 0.4 (C) 0.2 (D) 0.1

2. The maximum static frictional force is :
(A) Equal to twice the area of surface in contact (B) Independent of the area of surface in contact
(C) Equal to the area of surface in contact (D) None of the above

3. Maximum value of static friction is called
(A) Limiting friction (B) Rolling friction (C) Normal reaction (D) Coefficient of friction

4. In the figure shown, a block of weight 10 N resting on a horizontal surface. The coefficient of static friction between the block and the surface $\mu_s = 0.4$. A force of 3.5 N will keep the block in uniform motion, once it has been set in motion. A horizontal force of 3 N is applied to the block, then the block will :



(A) Move over the surface with constant velocity
(B) Move having accelerated motion over the surface
(C) Not move
(D) First will move with a constant velocity for some time and then will have accelerated motion

5. Starting from rest a body slides down a 45º inclined plane in twice the time it takes to slide down the same distance in the absence of friction. The co-efficient of friction between the body and the inclined plane is:
(A) 0.75 (B) 0.33 (C) 0.25 (D) 0.80

6. A 60 kg body is pushed with just enough force to start it moving across a floor and the same force continues to act afterwards. The coefficient of static friction and sliding friction are 0.5 and 0.4 respectively. The acceleration of the body is :
(A) 6 m/s^2 (B) 4.9 m/s^2 (C) 3.92 m/s^2 (D) 1 m/s^2

7. A 500 kg horse pulls a cart of mass 1500 kg along a level horizontal road with an acceleration of 1 ms^{-2}. If the coefficient of sliding friction between the cart and ground is 0.2, then the force exerted by the horse on the cart in forward direction is : (Assume limiting friction is acting)
(A) 3000 N (B) 4500 N (C) 5000 N (D) 6000 N

8. A fireman of mass 60 kg slides down a pole. He is pressing the pole with a force of 600 N. The coefficient of friction between the hands and the pole is 0.5, with what acceleration will the fireman slide down ($g = 10\ m/s^2$) :
(A) 1 m/s^2 (B) 2.5 m/s^2 (C) 10 m/s^2 (D) 5 m/s^2

9. A rope so lies on a table that part of it lays over. The rope begins to slide when the length of hanging part is 25 % of entire length. The co-efficient of friction between rope and table is :
(A) 0.33 (B) 0.25 (C) 0.5 (D) 0.2

10. A varying horizontal force $F = at$ acts on a block of mass m kept on a smooth horizontal surface. An identical block is kept on the first block. The coefficient of friction between the blocks is μ. The time after which the relative sliding between the blocks takes place is
(A) 2mg/a (B) $2\mu mg$ (C) $\mu mg/a$ (D) none of these

11. The coefficient of friction between a body and ground is $1/\sqrt{3}$ then
(A) The angle of friction can vary from 60^0 to 90^0
(B) The angle of friction can vary from 0^0 to 30^0
(C) The angle of friction can vary from 0^0 to 60^0
(D) The angle of friction can be vary from 30^0 to 90^0

12. Two bodies of identical mass are tied by an ideal string which

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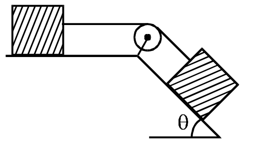
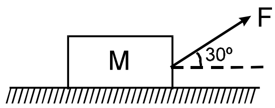
passes over an ideal pulley. The co-efficient of friction between the bodies and the plane is μ. The minimum value of θ for which the system starts moving is:



(A) $\cos^{-1}\left(\dfrac{\mu^2-1}{\mu^2+1}\right)$ (B) $\cos^{-1}\left(\dfrac{\mu^2+1}{1-\mu^2}\right)$ (C) $\cos^{-1}\left(\dfrac{2\mu}{1+\mu^2}\right)$ (D) $\theta = \cos^{-1}\left(\dfrac{1-\mu^2}{1+\mu^2}\right)$

13. A block of mass M = 5 kg is resting on a rough horizontal surface for which the coefficient of friction is 0.2. When a force F = 40 N is applied, the acceleration of the block will be (g = 10 m/s^2) :



(A) 5.73 m/sec^2 (B) 8.0 m/sec^2 (C) 3.17 m/sec^2 (D) 10.0 m/sec^2

14. A body of mass M is kept on a rough horizontal surface (friction coefficient = μ). A person is trying to pull the body by applying a horizontal force but the body is not moving. The force by the surface on A is F where

(A) F = Mg (B) F = μ Mg

(C) $Mg \le F \le Mg\sqrt{1+\mu^2}$ (D) $Mg \ge F \ge Mg\sqrt{1-\mu^2}$

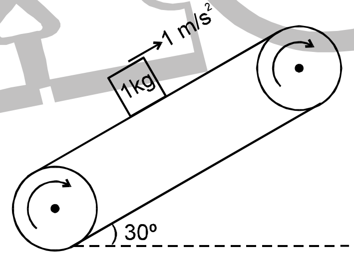
15. A block A kept on an inclined surface just begins to slide if the inclination is 30º. The block is replaced by another block B and it is found that it just begins to slide if the inclination is 40º.

(A) mass of A > mass of B (B) mass of A < mass of B
(C) mass of A = mass of B (D) Insufficient information.

16. A boy of mass M is applying a horizontal force to slide a box of mass M' on a rough horizontal surface. It is known that the boy does not slide . The coefficient of friction between the shoes of the boy and the floor is μ and μ' between the box and the surface. In which of the following cases it is certainly not possible to slide the box ?

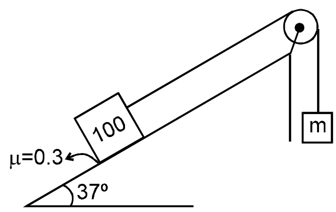
(A) $\mu < \mu'$, M < M' (B) $\mu > \mu'$, M < M'
(C) $\mu < \mu'$, M > M' (D) $\mu > \mu'$, M > M

17. A block of mass 1 kg is stationary with respect to a conveyer belt that is accelerating with 1 m/s^2 upwards at an angle of 30º as shown in figure. Which of the following is/are correct?



(A) Force of friction on block is 6 N upwards.
(B) Force of friction on block is 1.5 N upwards.
(C) Contact force between the block & belt is 10.5 N.
(D) Contact force between the block & belt is $5\sqrt{3}$ N.

18. The value of mass m for which the 100 kg block remains is static equilibrium is



(A) 35 kg (B) 37 kg
(C) 83 kg (D) 85 kg

19. Let F, F_N and f denote the magnitudes of the contact force , normal force and the friction exerted by one surface on the other kept in contact. If none of these is zero,

(A) F > F_N (B) F > f (C) F_N > f (D) $F_N - f < F < F_N + f$

20. The contact force exerted by one body on another body is equal to the normal force between the bodies. It can be said that :

(A) the surface must be frictionless
(B) the force of friction between the bodies is zero
(C) the magnitude of normal force equals that of friction
(D) it is possible that the bodies are rough and they do not slip on each other

21. Out of the following given statements, mark out the correct(s) :

(A) Static friction is always greater than the kinetic friction.
(B) Coefficient of static friction is always greater than the coefficient of kinetic friction.
(C) Limiting friction is always greater than the kinetic friction.
(D) Limiting friction is never less than the static friction.

22. A block is placed on a rough floor and a horizontal force F is applied on it. The force of friction f by the floor on the block is measured for different values of F and a graph is plotted between them.
(A) The graph is a straight line of slope 45º
(B) The graph is straight line parallel to the F-axis.
(C) The graph is a straight line of slope 45º for small F and a straight line parallel to the F-axis for large F.
(D) There is a small kink on the graph.

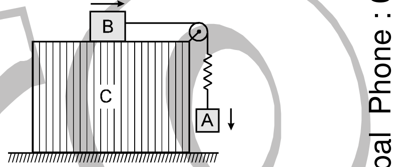
23. A worker wishes to pile a cone of sand into a circular area in his yard. The radius of the circle is r, and no sand is to spill onto the surrounding area. If μ is the static coefficient of friction between each layer of sand along the slope and the sand, the greatest volume of sand that can be stored in this manner is :

(A) $\mu\pi r^3$ (B) $\frac{1}{3}\mu\pi r^3$ (C) $2\mu\pi r^2$ (D) $2\mu\pi r$

24. The upper portion of an inclined plane of inclination α is smooth and the lower portion is rough. A particle slides down from rest from the top and just comes to rest at the foot. If the ratio of the smooth length to rough length is m : n, the coefficient of friction is :

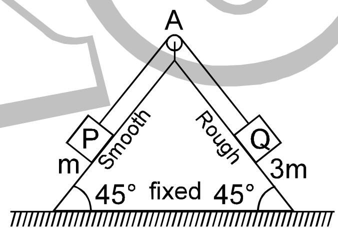
(A) $\left[\frac{m+n}{n}\right]\tan\alpha$ (B) $\left(\frac{m+n}{n}\right)\cot\alpha$ (C) $\left(\frac{m-n}{n}\right)\cot\alpha$ (D) $\frac{1}{2}$

25. Two blocks A & B are connected to each other by a string and a spring . The string passes over a frictionless pulley as shown in the figure . Block B slides over the horizontal top surface of a fixed block C and the block A slides along the vertical side of C with the same uniform speed . The coefficient of friction between the surfaces of the blocks is 0.2. The force constant of the spring is 1960 N m^{-1}. If the mass of the block A is 2 kg , What is the mass of block B, and the extension in the spring is : (g = 9.8 m/s^2)



(A) 5 kg, 5 cm (B) 2 kg, 4 cm
(C) 10 kg, 1 cm (D) 1 kg, 2 cm

26. A fixed wedge with both surface inclined at 45^0 to the horizontal as shown in the figure. A particle P of mass m is held on the smooth plane by a light string which passes over a smooth pulley A and attached to a particle Q of mass 3m which rests on the rough plane. The system is released from rest. Given that the acceleration of each particle is of magnitude $\frac{g}{5\sqrt{2}}$ then



(a) the tension in the string is :

(A) mg (B) $\frac{6mg}{5\sqrt{2}}$ (C) $\frac{mg}{2}$ (D) $\frac{mg}{4}$

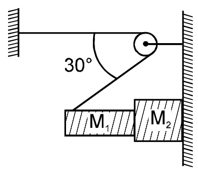
(b) In the above question the coefficient of friction between Q and the rough plane is :

(A) $\frac{4}{5}$ (B) $\frac{1}{5}$ (C) $\frac{3}{5}$ (D) $\frac{2}{5}$

(c) In the above question the magnitude and direction of the force exerted by the string on the pulley is :

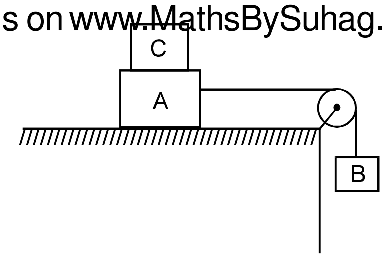
(A) $\frac{6mg}{5}$downward (B) $\frac{6mg}{5}$upward (C) $\frac{mg}{5}$downward (D) $\frac{mg}{4}$downward

27. Two blocks with masses m_1 and m_2 of 10 kg and 20 kg respectively are placed as in fig. μ_s = 0.2 between all surfaces, then tension in string and acceleration of m_2 block at this moment will be :



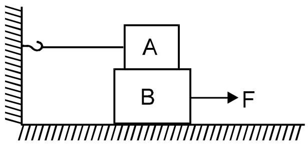
(A) 250 N, 3 m/s^2 (B) 200 N, 6 m/s^2 (C) 306 N, 4.7 m/s^2 (D) 400 N, 6.5 m/s^2

28. Two masses A and B of 10 kg and 5 kg respectively are connected with a string passing over a frictionless pulley fixed at the corner of a table as shown. The coefficient of static friction of A with table is 0.2. The minimum mass of C that may be placed on A to prevent it from moving is



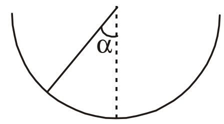
(A) 15 kg (B) 10 kg
(C) 5 kg (D) 12 kg

29. A block A with mass 100 kg is resting on another block B of mass 200 kg. As shown in figure a horizontal rope tied to a wall holds it. The coefficient of friction between A and B is 0.2 while coefficient of friction between B and the ground is 0.3. The minimum required force F to start moving B will be :



(A) 900 N (B) 100 N (C) 1100 N (D) 1200 N

30. An insect crawls up a hemispherical surface very slowly (see figure) . The coefficient of friction between the insect and the surface is 1/3. If the line joining the centre of the hemispherical surface to the insect makes an angle α with the vertical, the maximum possible value of α is given by :



(A) $\cot\alpha = 3$ (B) $\tan\alpha = 3$ (C) $\sec\alpha = 3$ (D) $\mathrm{cosec}\,\alpha = -3$

31. A body takes time t to reach the bottom of an inclined plane of angle θ with the horizontal. If the plane is made rough, time taken now is 2t. The coefficient of friction of the rough surface is :

(A) $\frac{3}{4}\tan\theta$ (B) $\frac{2}{3}\tan\theta$ (C) $\frac{1}{4}\tan\theta$ (D) $\frac{1}{2}\tan\theta$

32. A cart weighing 200 N can roll without friction along a horizontal path. The cart carries a block weighing 20 N. The coefficient of friction between the block and the cart is 0.25 and $g = 10\ m/s^2$.

(a) When a force of 2 N is applied to the block then

(i) The force of friction between the block and cart is

(A) $\frac{20}{11}$ N (B) $\frac{10}{11}$ N (C) $\frac{40}{11}$ N (D) $\frac{2}{11}$ N

(ii) Acceleration of the block and cart would be respectively :

(A) $\frac{1}{11}m/s^2, \frac{1}{11}m/s^2$ (B) $\frac{1}{9}m/s^2, \frac{1}{9}m/s^2$ (C) $\frac{1}{9}m/s^2, \frac{1}{11}m/s^2$ (D) $\frac{1}{6}m/s^2, \frac{1}{6}m/s^2$

(b) When a force of 20 N is applied to the block then

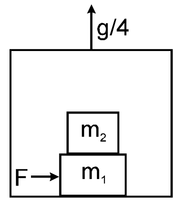
(i) The force of friction between the block and cart is

(A) 2 N (B) 5 N (C) 8 N (D) 6 N

(ii) Acceleration of the block and cart would be respectively:

(A) $7.5\ m/s^2, 0.25\ m/s^2$ (B) $0.25\ m/s^2, 7.5\ m/s^2$
(C) $7.5\ m/s^2, 7.5\ m/s^2$ (D) $0.25\ m/s^2, 0.25\ m/s^2$

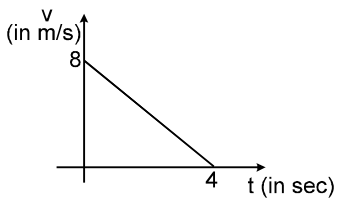
33. A plank of mass $M_1 = 8$ kg with a bar of mass $M_2 = 2$ kg placed on its rough surface, lie on a smooth floor of elevator ascending with an acceleration g/4. The coefficient of friction is $\mu = 1/5$ between m_1 and m_2. A horizontal force F = 30 N is applied to the plank. Then the acceleration of bar and the plank in the reference frame of elevator are :



(A) $3.5\ m/s^2, 5\ m/s^2$ (B) $5\ m/s^2, \frac{50}{8}\ m/s^2$

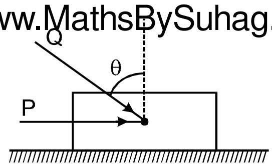
(C) $2.5\ m/s^2, \frac{25}{8}\ m/s^2$ (D) $4.5\ m/s^2, 4.5 m/s^2$

34. A block of mass 2 kg is given a push horizontally and then the block starts. Sliding over a horizontal plane. The graph shows the velocity - time graph of the motion. The coefficient of kinetic friction between the plane and the block is :



(A) 0.02 (B) 0.2
(C) 0.04 (D) 0.4

35. A block of mass m lying on a rough horizontal plane is acted upon by a horizontal force P and another force Q inclined an at an angle θ to the vertical. The minimum value of coefficient of friction between the block and the surface for which the block will remain in equilibrium is :



(A) $\frac{P+Q\sin\theta}{mg+Q\cos\theta}$ (B) $\frac{P\cos\theta+Q}{mg-Q\sin\theta}$ (C) $\frac{P+Q\cos\theta}{mg+Q\sin\theta}$ (D) $\frac{P\sin\theta-Q}{mg-Q\cos\theta}$

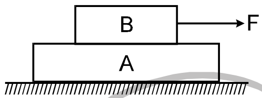
36. A block moves down a smooth inclined plane of inclination θ, its velocity on reaching the bottom is v. If it slides down a rough inclined plane of same inclination, its velocity on reaching the bottom is v/n, where n is a number greater than one. The coefficient of friction is given by

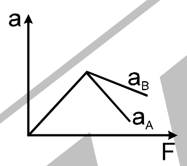
(A) $\mu = \tan\theta\left(1-\frac{1}{n^2}\right)$ (B) $\mu = \cot\theta\left(1-\frac{1}{n^2}\right)$ (C) $\mu = \tan\theta\left(1-\frac{1}{n^2}\right)^{1/2}$ (D) $\mu = \cot\theta\left(1-\frac{1}{n^2}\right)^{1/2}$

37. A uniform chain of mass M and length L is lying on a table in such a manner that a part of it is hanging down from an edge of the table. If coefficient of friction is μ, then the maximum length of the chain that can hang without sliding is :

(A) $\frac{L}{\mu}$ (B) $\frac{L}{\mu-1}$ (C) $\frac{\mu L}{\mu-1}$ (D) $\frac{\mu L}{\mu+1}$

38. A wooden block A of mass M is placed on a frictionless horizontal surface. On top of A, another lead block B also of mass M is placed. A horizontal force of magnitude F is applied to B. Force F is increased continuously from zero. The graphs below show the dependence of acceleration of the two blocks on the force F. Which of the graphs is correct. [$\mu_k < \mu_s$]



(A)


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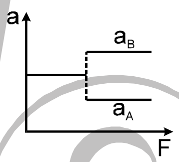

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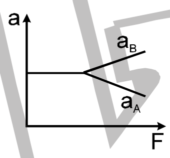
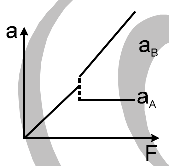
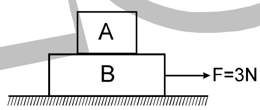


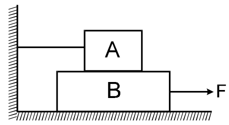
(D)


39. In the arrangement shown mass of A = 1 kg, mass of B = 2kg and coefficient of friction between A and B is 0.2. There is no friction between B and ground. The frictional force on A is (g = 10 m/s²).



(A) 0 N (B) 2 N
(C) 1.96 N (D) 1 N.

40. A is a 100 kg block and B is a 200 kg block. As shown in figure, the block A is attached to a string tied to a wall. The coefficient of friction between A and B is 0.2 and the coefficient of friction between B and floor is 0.3. Then the minimum force required to move the block B will be (g = 10 m/s²)

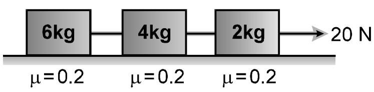


(A) 600 N (B) 800 N (C) 900 N (D) 1100 N

41. Two similar wooden blocks are tied one behind the other and pulled across a level surface. Friction is not negligible. The force required to pull them at constant speed is F. If one block is stacked upon the other then the new force required to pull then at constant speed will be approximately

(A) $\frac{F}{2}$ (B) F (C) $\sqrt{2}$ F (D) 2 F

42. (I) In the arrangement shown tension in the string connecting 4kg and 6kg masses is



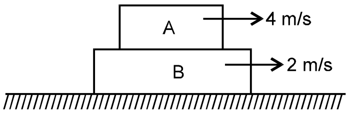
(A) 8N (B) 12N
(C) 6N (D) 4N

(II) Friction force on 4 kg block is
(A) 4N (B) 6 N (C) 12 N (D) 8 N

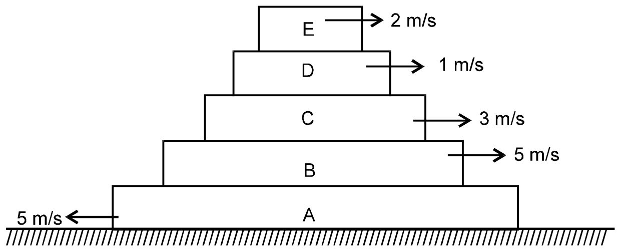
(III) Friction force on 6 kg block is
(A) 12 N (B) 8 N (C) 6 N (D) 4 N

SUBJECTIVE PROBLEMS

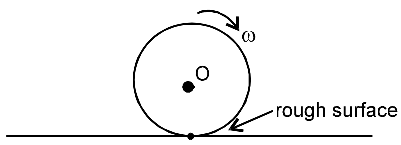
43. All surfaces are rough. Find the direction of friction forces on each block and ground at this instant.



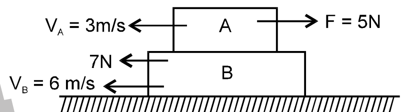
44. Find the direction of friction forces on each block and the ground (Assume all surfaces are rough and all velocities are with respect to ground).



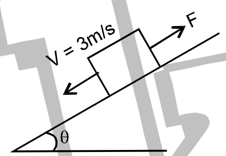
45. The wheel shown is fixed at 'O' and is in contact with a rough surface as shown . The wheel rotates with an angular velocity ω. What is the direction and nature of friction force on the wheel and on the ground.



46. In the following figure, find the direction of friction on the blocks and ground .



47. In the following figure, find the direction and nature of friction on the block.



48. An object is slowing down on a rough horizontal plane with a deceleration of $2 m/s^2$. What is the coefficient of kinetic friction

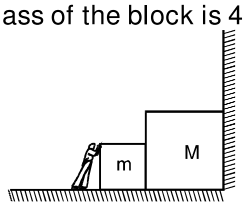
49. A block is shot with an initial velocity $5 ms^{-1}$ on a rough horizontal plane. Find the distance covered by the block till it comes to rest. The coefficient of kinetic friction between the block and plane is 0.1.

50. A block starting from rest slides down 18 m in three seconds on an inclined plane of 30º inclination. Find the coefficient of kinetic friction between the two.

51. A block begins to slide on a rough inclined plane and moves 1 meter in 0.707 seconds. What was the time taken to cover the first half meter on the incline.

52. Suppose the block of the previous problem is pushed down the incline with a force of 4N. How far will the block move in the first two seconds after starting from rest? The mass of the block is 4 kg.

53. The person applies F force on the smaller block as shown in figure. The coefficient of static friction is μ between the blocks and the surface. Find the force exerted by the vertical wall on mass M . What is the value of action-reaction forces between m and M?

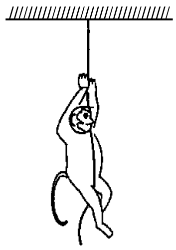


54. Determine the force and its direction on 2 kg block in the above situation. It is known that the two blocks move together. Can we determine the coefficient static friction between the two blocks. If yes then what is its value?

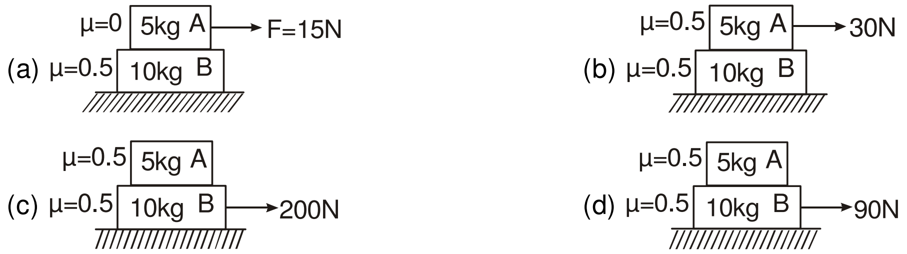
55. A block of mass 2.5 kg is kept on a rough horizontal surface . It is found that the block does not slide if a horizontal force less than 15 N is applied to it. Also it is found that it takes 5 seconds to slide throughout the first 10 m if a horizontal force of 15 N is applied and the block is gently pushed to start the motion. Taking g= 10 m/s^2, calculate the coefficients of static and kinetic friction between the block and the surface.

56. The angle between the resultant contact force and the normal force exerted by a body on the other is called the angle of friction. Show that, if λ be the angle of friction and μ the coefficient of static friction, $\lambda \le \tan^{-1}\mu$

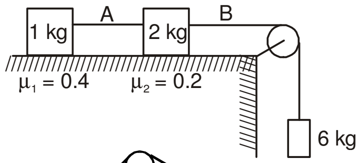
57. A monkey of mass m is climbing a rope hanging from the roof with acceleration a. The coefficient of static friction between the body of the monkey and the rope is μ. Find the direction and value of friction force on the monkey.



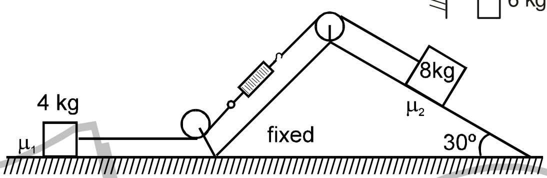
58. Find the accelerations and the friction forces involved :



59. Calculate the accelerations of the blocks and the tension in the string A & B. If the 6 kg block is replaced by a 0.3 kg block, find the new accelerations and tension in the strings A & B.

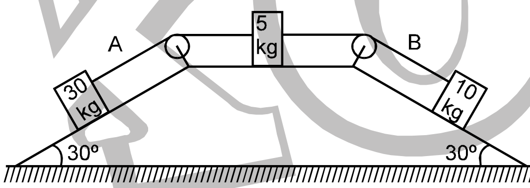


60. The reading of spring balance is 32 N and the accelerations of both the blocks is 0.5 m/s^2. Find μ_1 and μ_2.



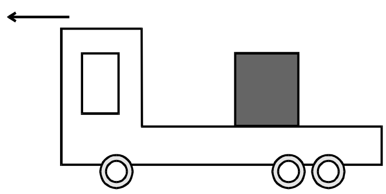
61. A block of mass 15 kg is placed on a long trolley. The coefficient of static friction between the block and the trolley is 0.18. The trolley accelerates from rest with 0.5 m s^{-2} for 20 s and then moves with uniform velocity. Discuss the motion of the block as viewed by (a) a stationary observer on the ground. (B) an observer fixed with respect to the trolley.

62. The coefficient of friction between 5 kg block and the surface is 0.2. Inclined surfaces are smooth. Find the tension in the strings.

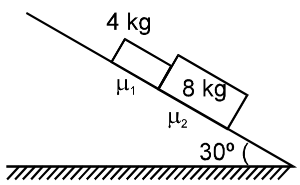


63. The friction coefficient between an athlete's shoes and the ground is 0.90. Suppose a superman wears these shoes and races for 50 m. There is no upper limit on his capacity of running at high speeds. (a) Find the minimum time that he will have to take in completing the 50 m starting from rest. (B) Suppose he takes exactly this minimum time to complete the 50 m , what minimum time will he take to stop ?

64. The rear side of a truck is open and a box of 40 kg mass is placed 5 m away from the open end as shown in figure. The coefficient of friction between the box and the surface below it is 0.15. On a straight road, the truck starts from rest and accelerates with 2 ms^{-2}. At what distance from the starting point of the truck does the box fall off the truck? (Ignore the size of the box).

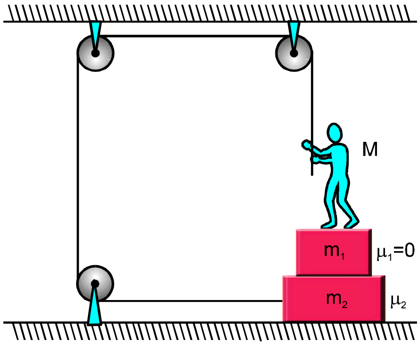


65. In the figure shown below the friction between the 4 kg block and the incline as μ_1 and between 8 kg and incline is μ_2. Calculate the accelerations of the blocks when (a) μ_1 = 0.2 and μ_2 = 0.3 (b) μ_1 = 0.3 and μ_2 = 0.2. (take g = 10 m/s^2)

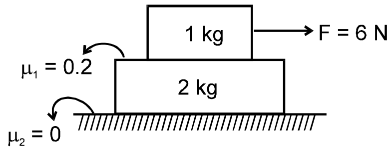


66. What is the minimum value of force required to pull a block of mass M on a horizontal surface having coefficient of friction μ? Also find the angle this force makes with the horizontal.

67. Find the maximum force with which the man can pull the rope such that the mass m_2 does not slide. Find the minimum value of μ_2 if it is known that the blocks do not slide even if the man hangs himself on the rope. Can the value of coefficient of friction be greater than 1?

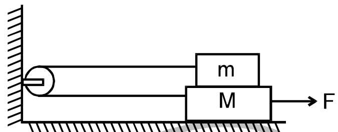


68. In the situation shown above find the accelerations of the blocks. Also find the accelerations if the force is shifted from the upper block to the lower block.



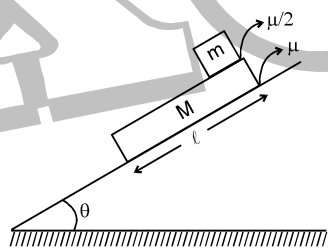
69. A plank of mass m_1 with a bar of mass m_2 placed on it lies on a smooth horizontal plane. A horizontal force growing with time t as F = kt (k is constant) is applied to the bar. Find how the accelerations of the plank a_1 and of the bar a_2 depend on t, if the coefficient of friction between the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

70. In the situation shown below all the surfaces in contact have coefficient μ. (a) What is the maximum F that can be applied so that the equilibirium of system is not disturbed. (b) If the force exerted is double that of what is found in (a), find the accelerations of blocks.



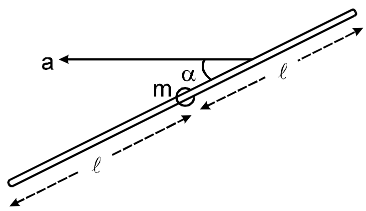
71. If the system of above question is placed in an elevator moving upwards with an acceleration a, repeat the parts (a) and (b).

72. A block of mass 2 kg is pushed against a rough vertical wall with a force of 40 N, coefficient of static friction being 0.5. Another horizontal force of 15 N is applied on the block in a direction parallel to the wall. Will the block move ? If yes , in which direction ? If no, find the frictional force exerted by the wall on the block.



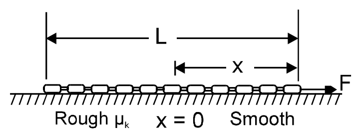
73. In the above situation it is known that when released the blocks slide. Find the accelerations of the two blocks. Also find the time when the small block will fall off from the larger block.

74. A bead of mass 'm' is fitted onto a rod with a length of 2ℓ, and can move on it with friction having the coefficient of friction μ. At the initial moment the bead is in the middle of the rod. The rod moves translationally in a horizontal plane with an acceleration 'a' in the direction forming an angle α with the rod. The time when the bead will leave the rod is : (Neglect the weight of the bead).

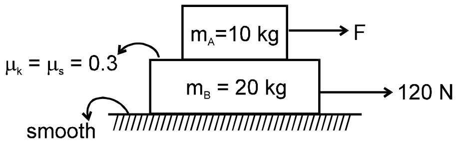


75. A block lying on a long horizontal conveyor belt moving at a constant velocity receives a velocity 5 m/s relative to the ground in the direction opposite to the direction of motion of the conveyor. After t = 4 sec, the velocity of the block becomes equal to the velocity of the belt. The coefficient of friction between the block and the belt is 0.2. Then the velocity of the conveyor belt is:

76. 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 of the chain when x = L, if the force F is greater than $\mu_k \rho gL$ in order to initiate the motion is :

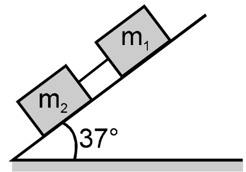


77. In the above situation force F is gradually increased from zero. Discuss the direction and nature of friction and the accelerations of the block at different values of F (Take g = 10 m/s²).



EXERCISE-2

1. Two blocks m_1 = 4kg and m_2 = 2kg, connected by a weightless rod on a plane having inclination of 37^0. The coefficients of dynamic friction of m_1 and m_2 with the inclined plane are μ = 0.25. Then the common acceleration of the two blocks and the tension in the rod are : **[JEE 1979]**



(A) 4 m/s², T = 0 (B) 2 m/s², T = 5 N
(C) 10 m/s², T = 10 N (D) 15 m/s², T = 9N

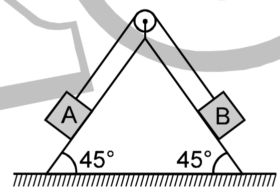
2. A block of mass 2 kg rests on a rough inclined plane making an angle of 30^0 with the horizontal. The coefficient of static friction between the block and the plane is 0.7. The frictional force on the block is : **[IIT 1980]**

(A) 9.8 N (B) 0.7 × 9.8 $\sqrt{3}$ N (C) 9.8 × 7 N (D) 0.8 × 9.8 N

3. A block of mass 1 kg lies on a horizontal surface in a truck. The coefficient of static friction between the block and the surface is 0.6 If the acceleration of the truck is 5 m/s², the frictional force acting on the block is : **[JEE 1984]**
(A) 5 N (B) 6 N (C) 10 N (D) 15 N

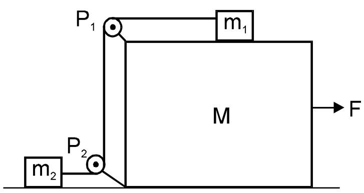
4. A block of mass 0.1kg is held against a wall by applying a horizontal force of 5 N on the block. If the coefficient of friction between the block and the wall is 0.5, the magnitude of the friction force acting on the block is : **[JEE 1997, 3/100]**
(A) 2.5 N (B) 0.98 N (C) 4.9 N (D) 0.49 N

5. Block A of mass m and block B of mass 2 m are placed on a fixed triangular wedge by means of a massless inextensible string and a frictionless pulley as shown in figure. The wedge is inclined at 45º to the horizontal on both sides. The coefficient of friction between block A and the wedge is 2/3 and that between block B and the wedge is 1/3. If the system of A and B is released from rest, find **[JEE 1997,5/100]**



(i) the acceleration of A (ii) tension in the string
(iii) the magnitude and the direction of friction acting on A.

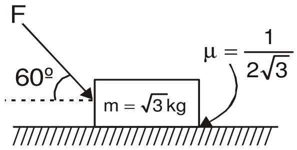
6. In the figure masses m_1, m_2 and M are 20 kg, 5 kg and 50 kg respectively . The coefficient of friction between M & ground is zero. The coefficient of friction between m_1 & M and that between m_2 & ground is 0.3 . The pulleys & the string are massless . The string is perfectly horizontal between P_1 & m_1 and also between P_2 & m_2 . The string is perfectly vertical between P_1 & P_2 . An external horizontal force F is applied to the mass M. [Take g = 10 m/s²] ***[JEE 2000, 2+8/100]***



(a) Draw a free–body diagram for mass M, clearly showing all the forces.
(B) Let the magnitude of the force of friction between m_1 and M be f_1 and that between m_2 and ground be f_2. For a particular F it is found that f_1 = 2 f_2. Find f_1 and f_2. Write down equations of motion of all the masses. Find F, tension in the string and accelerations of the masses.

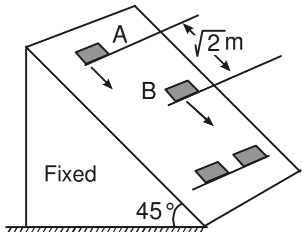
7. What is the maximum value of the force F such that the block shown in the arrangement, does not move :

[IIT–JEE (Scr.) 2003]



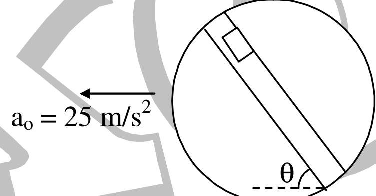
(A) 20 N (B) 10 N (C) 12 N (D) 15 N

8. Two blocks A and B of equal masses are sliding down along straight parallel lines on an inclined plane of 45°. Their coefficients of kinetic friction are $\mu_A = 0.2$ and $\mu_B = 0.3$ respectively. At t = 0, both the blocks are at rest and block A is $\sqrt{2}$ meter behind block B. The time and distance from the initial A position where the front faces of the blocks come in line on the inclined plane as shown in figure. (Use g = 10 ms^{-2}.) **[JEE 2004, 3/60]**



(A) 2s, $8\sqrt{2}$ m (B) $\sqrt{2}$ s, 7m (C) $\sqrt{2}$ s, $7\sqrt{2}$ m (D) 2s, $7\sqrt{2}$ m

9. A disc is kept on a smooth horizontal plane with its plane parallel to horizontal plane. A groove is made in the disc as shown in the figure. The coefficient of friction between a mass m inside the groove and the surface of the groove is 2/5 and sin θ = 3/5. Find the acceleration of mass with respect to the frame of reference of the disc. **[JEE 2006, 6/184]**



ANSWER

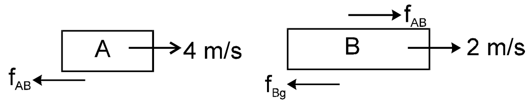
EXERCISE # 1

OBJECTIVE PROBLEMS

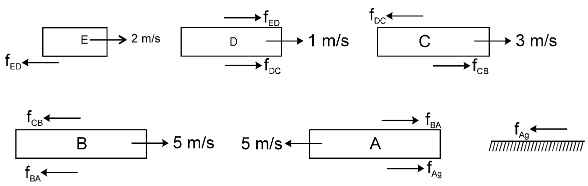
1. D	**2.** B	**3.** A	**4.** C
5. A	**6.** D	**7.** B	**8.** D
9. A	**10.** D	**11.** B	**12.** D
13. A	**14.** C	**15.** A,B,C	**16.** A
17. A,C	**18.** B,C	**19.** A,B,D	**20.** B,D
21. B,C,D	**22.** C,D	**23.** B	**24.** A
25. C	**26.** (a) B (b) D (c) A		**27.** C
28. A	**29.** C	**30.** A	**31.** A
32. (a) (i) D (ii) A (b) (i) B (ii) A			
33. C	**34.** B	**35.** A	**36.** A
37. D	**38.** D	**39.** D	**40.** D
41. B	**42.** (I) A (II) D (III) B		

SUBJECTIVE PROBLEMS

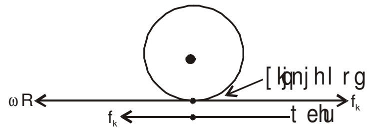
43.



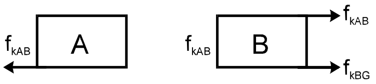
44.



45.



Kinetic friction is involved.

46. 

47. Up the incline, kinetic friction. **48.** 0.2

49. $V_f^2 - V_i^2 = 2as \Rightarrow \frac{25}{2\times 1} = 12.5$ m

50. 0.11 **51.** 1/2 second **52.** 10m

53. N = 0 for $F \le \mu(M+m)g$
N= $F - \mu(M+m)g$ for $F > \mu(M+m)g$
action-reaction forces between m and M is $F - \mu mg$ for $F > \mu mg$ and 0 for $F < \mu mg$

54. 2 N, $\mu \ge 0.1$

55. $\mu_s = 0.60$, $\mu_k = 0.52$

57. Upwards, $f = m(g+a)$

58. (a) $a_A = 3$ m/s², $a_B = 0$, $f_A = 0$, $f_B = 0$
(b) **$a_A = 1$ m/s², $a_B = 0$, $f_A = 25$N, $f_B = 25$N**
(c) **$a_A = 5$ m/s²; $a_B = 10$ m/s²; $f_A = 25$N; $f_B = 75$N**
(d) **$a_A = 1$m/s²; $a_B = 1$m/s²; $f_A = 5$N; $f_B = 75$N**

59. 52/9 m/s², T_A= 88/9, T_B= 76/3 N ; 0 m/s², T_A= 0 N, T_B= 3 N

60. $\mu_1 = 0.75$, $\mu_2 = 0.06$

62. 90 N in string A, 70 N in string B.

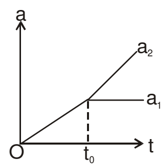
63. (**a**) $\frac{10}{3}$ **s** (**B**) $\frac{10}{3}$ **s** **64.** 20 m

65. (a) 2.4 m/s² both ; (b) 3.2 m/s², 2.4 m/s²

66. $\frac{\mu Mg}{\sqrt{1+\mu^2}}$, $\tan^{-1}\mu$. **67.** $\frac{\mu_2(M+m_1+m_2)g}{1+\mu_2}$, $\frac{M}{m_1+m_2}$

68. Upper block 4 m/s², lower block 1 m/s² ; Both blocks 2 m/s²

69. When $t \le t_0$, the accelerations $a_1 = a_2 = kt/(m_1+m_2)$; when $t \ge t_0$
$a_1 = \mu g m_2 / m_1$, $a_2 = (at - \mu m_2 g)/m_2$. Here $t_0 = \mu g m_2 (m_1 + m_2)/km$.



70. (a) $\mu(M+3m)g$, (b) $\frac{\mu(M+3m)g}{M+m}$

71. (a) $\mu(M+3m)(g+a)$, (b) $\frac{\mu(M+3m)(g+a)}{M+m}$

72. It will move at an angle of 53º with the 15N force

73. $a_m = g\sin\theta - \frac{\mu}{2} g\cos\theta$;

$$a_M \; \frac{Mg\sin\theta + \frac{\mu}{2}mg\cos\theta - \mu(M+m)g\cos\theta}{M};$$

$$t = \sqrt{\frac{4\ell M}{\mu g\cos\theta(M+m)}}.$$

74. $\sqrt{\frac{2\ell}{a(\cos\alpha - \mu\sin\alpha)}}$ **75.** 3 m/s **76.** $\sqrt{\frac{2F}{\rho} - \mu_k gL}$

77. $F = 0$ $\begin{cases} a_A = 3\,m/s^2 \\ a_B = 4.5\,m/s^2 \end{cases}$ kinetic friction and $f = 30$ N

$0 < F \le 15$ $\begin{cases} 3 < a_A \le 4.5\,m/s^2 \\ a_B = 4.5\,m/s^2 \end{cases}$ kinetic friction in same direction as above and f = 30 N

$15 < F \le 60$ {$4.5 < a_A = a_B \le 6$ m/s²
static friction, variable and in same direction.

$60 < F \le 105$ N { $6 < a_A = a_B < 7.5$ m/s²
static friction, variable and in opposite direction to the previous parts.

$F > 105$ N $\begin{cases} a_A > 7.5\,m/s^2 \\ a_B = 7.5\,m/s^2 \end{cases}$

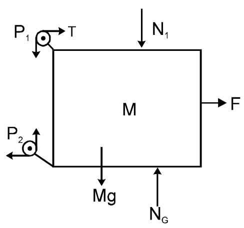
Kinetic friction and in opposite direction to the previous parts

EXERCISE # 2

1. A **2.** A **3.** A **4.** B

5. (i) zero (ii) $\frac{2\sqrt{2}}{3}$mg (iii) $\frac{mg}{3\sqrt{2}}$, downwards

6. **F = 60 N, T = 18 N,** $a_{m1} = a_{m2} = a_M = 0.6\,m/s^2$



7. A **8.** A **9.** 10 m/s²

