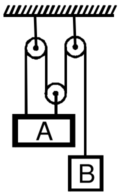
Exercise - I (Objective Problems)

(A) NEWTON'S LAW OF MOTION

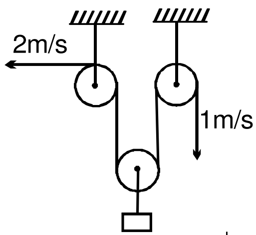
1. At a given instant, A is moving with velocity of 5 m/s upwards. What is velocity of B at the time



(A) 15 m/s↓ (B) 15 m/s↑ (C) 5 m/s ↓ (D) 5 m/s ↑

Sol.

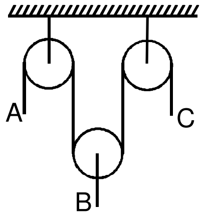
2. Find the velocity of the hanging block if the velocities of the free ends of the rope are as indicated in the figure.



(A) 3/2 m/s ↑ (B) 3/2 m/s ↓
(C) 1/2 m/s ↑ (D) 1/2 m/s ↓

Sol.

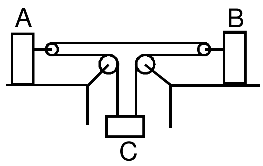
3. The pulleys in the diagram are all smooth and light. The acceleration of A is a upwards and the acceleration of C is f downwards. The acceleration of B is



(A) 1/2 (f – a) up (B) 1/2 (a + f) down
(C) 1/2 (a + f) up (D) 1/2 (a – f) up

Sol.

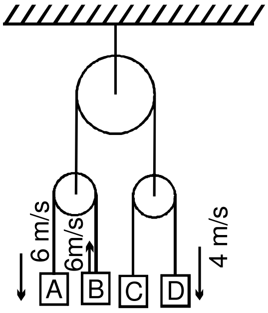
4. If acceleration of A is 2 m/s^2 to left and acceleration of B is 1 m/s^2 to left, then acceleration of C is -



(A) 1 m/s^2 upwards (B) 1 m/s^2 downwards
(C) 2 m/s^2 downwards (D) 2 m/s^2 upwards

Sol.

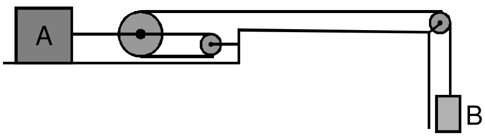
5. In the figure shown the velocity of different blocks is shown. The velocity of C is



(A) 6 m/s (B) 4 m/s
(C) 0 m/s (D) none of these

Sol.

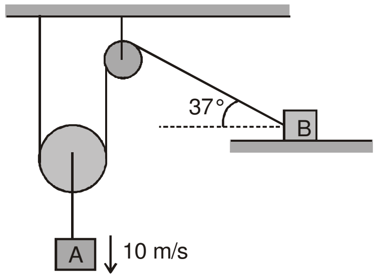
6. If block A has a velocity of 0.6 m/s to the right, determine the velocity of block B.



(A) 1.8 m/s in downward direction
(B) 1.8 m/s in upward direction
(C) 0.6 m/s in downward direction
(D) 0.6 m/s in upward direction

Sol.

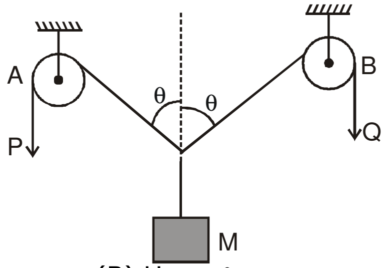
7. Find velocity of block 'B' at the instant shown in figure.



(A) 25 m/s (B) 20 m/s
(C) 22 m/s (D) 30 m/s

Ans.

8. In the arrangement shown in fig. the ends P and Q of an unstretchable string move downwards with uniform speed U. Pulleys A and B are fixed. Mass M moves upwards with a speed.

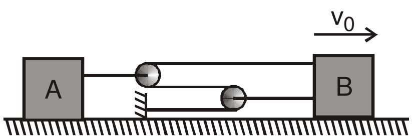


(A) 2 U cos θ (B) U cos θ

(C) $\frac{2U}{\cos\theta}$ (D) $\frac{U}{\cos\theta}$

Sol.

9. Block B moves to the right with a constant velocity v_0. The velocity of body A relative to B is :

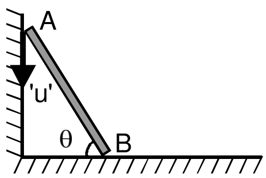


(A) $\frac{v_0}{2}$, towards left (B) $\frac{v_0}{2}$, towards right

(C) $\frac{3v_0}{2}$, towards left (D) $\frac{3v_0}{2}$, towards right

Sol.

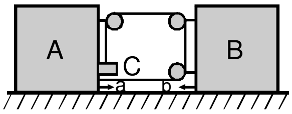
10. The velocity of end 'A' of rigid rod placed between two smooth vertical walls moves with velocity 'u' along vertical direction. Find out the velocity of end 'B' of that rod, rod always remains in constant with the vertical walls.



(A) u tan 2θ (B) u cot θ
(C)u tan θ (D) 2u tan θ

Sol.

11. Find the acceleration of C w.r.t. ground.

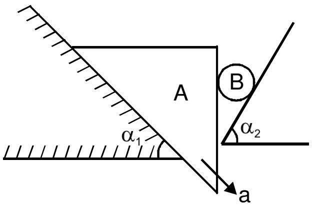


(A) $a\hat{i}-(2a+2b)\hat{j}$ (B) $a\hat{i}-(2a+b)\hat{j}$

(C) $a\hat{i}-(a+2b)\hat{j}$ (D) $b\hat{i}-(2a+2b)\hat{j}$

Sol.

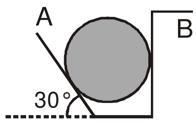
12. Find the acceleration of B.



(A) $\frac{a\cos\alpha_1}{\cos\alpha_2}$ (B) $\frac{a\sin\alpha_1}{\cos\alpha_2}$ (C) $\frac{a\cos\alpha_2}{\cos\alpha_1}$ (D) $\frac{\cos\alpha_1}{\cos\alpha_2}$

Sol.

13. The 50 kg homogeneous smooth sphere rests on the 30° incline A and bears against the smooth vertical wall B. Calculate the contact forces at A and B.



(A) $N_B = \frac{1000}{\sqrt{3}}N$, $N_A = \frac{500}{\sqrt{3}}N$

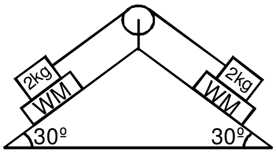
(B) $N_A = \frac{1000}{\sqrt{3}}N$, $N_B = \frac{500}{\sqrt{3}}N$

(C) $N_A = \frac{100}{\sqrt{3}}N$, $N_B = \frac{500}{\sqrt{3}}N$

(D) $N_A = \frac{1000}{\sqrt{3}}N$, $N_B = \frac{50}{\sqrt{3}}N$

Sol.

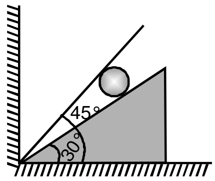
14. Find out the reading of the weighing machine in the following cases.



(A) $10\sqrt{3}$ (B) $10\sqrt{2}$ (C) $20\sqrt{3}$ (D) $30\sqrt{3}$

Sol.

15. A sperical ball of mass m = 5 kg rests between two planes which make angles of 30° and 45° respectively with the horizontal. The system is in equilibrium. Find the normal forces exerted on the ball by each of the planes. The planes are smooth.

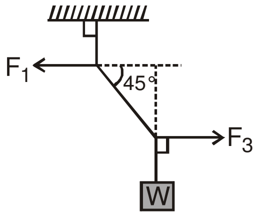


(A) N_{45} = 96.59 N, N_{30} = 136.6 N
(B) N_{30} = 96.59 N, N_{45} = 136.6 N
(C) N_{45} = 136.6 N, N_{30} = 96.56 N
(D) none of these

Sol.

Question No. 16 to 17 (2 questions)

In the figure the tension in the diagonal string is 60 N.



16. Find the magnitude of the horizontal force $\vec{F}_1$ and $\vec{F}_2$ that must be applied to hold the system in the position shown.

(A) $\frac{60}{\sqrt{3}}$ N (B) $\frac{20}{\sqrt{2}}$ N (C) $\frac{40}{\sqrt{2}}$ N (D) $\frac{60}{\sqrt{2}}$ N

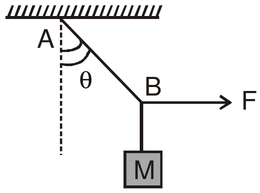
Sol.

17. In the above questions what is the weight of the suspended block ?

(A) $\frac{60}{\sqrt{2}}$ N (B) $\frac{40}{\sqrt{2}}$ N (C) $\frac{60}{\sqrt{3}}$ N (D) $\frac{50}{\sqrt{2}}$ N

Sol.

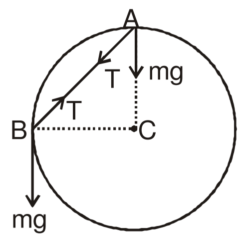
18. A mass M is suspended by a rope from a rigid support at A as shown in figure. Another rope is tied at the end B, and it is pulled horizontally with a force F. If the rope AB makes an angle θ with the vertical in equilibrium, then the tension in the string AB is :



(A) F sin θ (B) F/sin θ (C) F cos θ (D) F/cos θ

Sol.

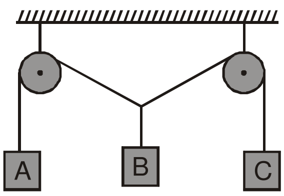
19. Objects A and B each of mass m are connected by light inextensible cord. They are constrained to move on a frictionless ring in a vertical plane as shown in figure. The objects are released from rest at the positions shown. The tension in the cord just after release will be



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

Sol.

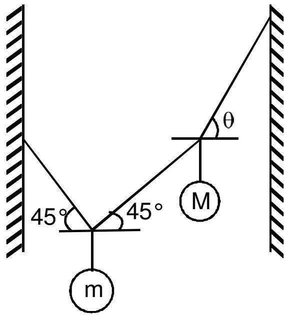
20. Three blocks A, B and C are suspended as shown in the figure. Mass of each blocks A and C is m. If system is in equilibrium and mass of B is M, then :



(A) M = 2m (B) M < 2 m (C) M > 2m (D) M = m

Sol.

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

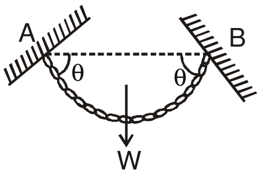


(A) $\tan\theta = 1 + \frac{2M}{m}$ (B) $\tan\theta = 1 + \frac{2m}{M}$

(C) $\cot\theta = 1 + \frac{2M}{m}$ (D) $\cot\theta = 1 + \frac{2m}{M}$

Sol.

22. A flexible chain of weight W hangs between two fixed points A & B which are at the same horizontal level. The inclination of the chain with the horizontal at both the points of support is θ. What is the tension of the chain at the mid point ?

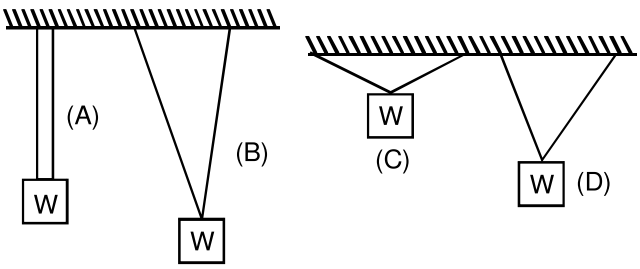


(A) $\frac{W}{2}.\mathrm{cosec}\theta$ (B) $\frac{W}{2}.\tan\theta$

(C) $\frac{W}{2}.\cot\theta$ (D) none

Sol.

23. A weight can be hung in any of the following four ways by string of same type. In which case is the string most likely to break ?



(A) A (B) B (C) C (D) D

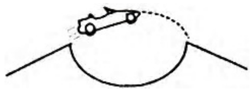
Sol.

24. A stunt man jumps his car over a crater as shown (neglect air resistance)

(A) during the whole flight the driver experiences weightlessness

(B) during the whole flight the driver never experiences weightlessness

(C) during the whole flight the driver experiences weightlessness only at the highest point

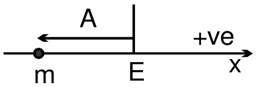


(D) the apparent weight increases during upward journey

Sol.

Question No. 25 to 27 (3 questions)

A particle of mass m is constrained to move on x-axis. A force F acts on the particle. F always points toward the position labeled E. For example, when the particle is to the left of E, F points to the right. The magnitude of F is constant except at point E where it is zero.



The system is horizontal. F is the net force acting on the particle. The particle is displaced a distance A towards left from the equilibrium position E and released from rest at t = 0

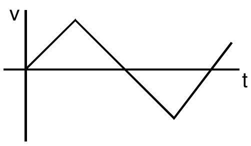
25. What is the period of the motion ?

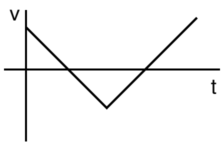
(A) $4\left(\sqrt{\frac{2Am}{F}}\right)$ (B) $2\left(\sqrt{\frac{2Am}{F}}\right)$

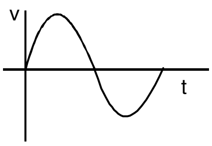
(C) $\left(\sqrt{\frac{2Am}{F}}\right)$ (D) None

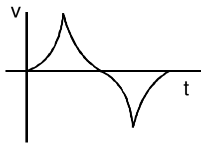
Sol.

26. Velocity-time graph of the particle is

(A) 

(B) 

(C) 

(D) 

Sol.

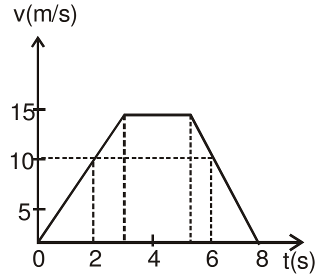
27. Find minimum time it will take to reach from $x = -\frac{A}{2}$ to 0.

(A) $\frac{3}{2}\sqrt{\frac{mA}{F}}(\sqrt{2}-1)$ (B) $\sqrt{\frac{mA}{F}}(\sqrt{2}-1)$

(C) $2\sqrt{\frac{mA}{F}}(\sqrt{2}-1)$ (D) none

Sol.

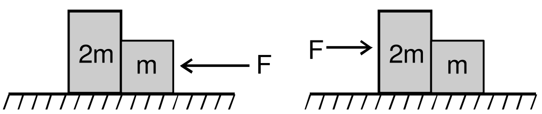
28. A particle of mass 50 gram moves on a straight line. The variation of speed with time is shown in figure. find the force acting on the particle at t = 2, 4 and 6 seconds.



(A) 0.25 N along motion, zero, 0.25 opposite to motion
(B) 0.25 N along motion, zero, 0.25 along to motion
(C) 0.25 N opposite motion, zero, 0.25 along to motion
(D) 0.25 N opposite motion, zero, 0.25 opposite to motion

Sol.

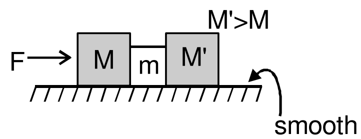
29. Two blocks are in contact on a frictionless table. One has mass m and the other 2m. A force F is applied on 2m as shown in the figure. Now the same force F is applied from the right on m. In the two cases respectively, the ratio force of contact between the two block will be :



(A) same (B) 1 : 2 (C) 2 : 1 (D) 1 : 3

Sol.

30. A constant force F is applied in horizontal direction as shown. Contact force between M and m is N and between m and M' is N' then

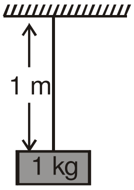


(A) N or N' equal (B) N > N'
(C) N' > N (D) cannot be determined

Sol.

Question No. 31 to 33 (3 questions)

A block of mass 1kg is suspended by a string of mass 1 kg, length 1m as shown in figure. (g = 10 m/s²) Calculate :



31. The tension in string at its lowest point.

(A) 10 N (B) 15 N (C) 20 N (D) 25 N

Sol.

32. The tension in string at its mid-point

(A) 10 N (B) 15 N (C) 20 N (D) 25 N

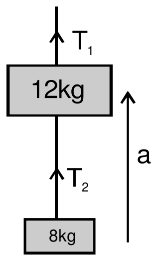
Sol.

33. Force exerted by support on string.

(A) 10 N (B) 15 N (C) 20 N (D) 25 N

Sol.

34. A body of mass 8 kg is hanging another body of mass 12 kg. The combination is being pulled by a string with an acceleration of 2.2 m s^{-2}. The tension T_1 and T_2 will be respectively : (use g = 9.8 m/s^2)



(A) 200 N, 80 N (B) 220 N, 90 N

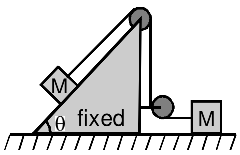
(C) 240 N, 96 N (D) 260 N, 96 N

Sol.

35. A rope of mass 5 kg is moving vertically in vertical position with an upwards force of 100 N acting at the upper end and a downwards force of 70 N acting at the lower end. The tension at midpoint of the rope is
(A) 100 N (B) 85 N (C) 75 N (D) 105 N
Sol.

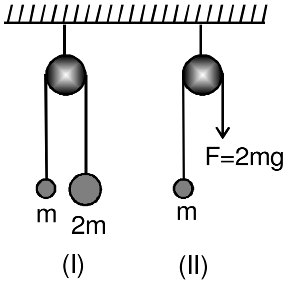
36. A particle of small mass m is joined to a very heavy body by a light string passing over a light pulley. Both bodies are free to move. The total downward force in the pulley is
(A) mg (B) 2 mg
(C) 4 mg (D) can not be determined
Sol.

37. Two blocks, each having mass M rest on frictionless surfaces as shown in the figure. If the pulleys are light and frictionless, and M on the incline is allowed to move down, then the tension in the string will be



(A) $\frac{2}{3}Mg\sin\theta$ (B) $\frac{3}{2}Mg\sin\theta$
(C) $\frac{Mg\sin\theta}{2}$ (D) $2\ Mg\sin\theta$
Sol.

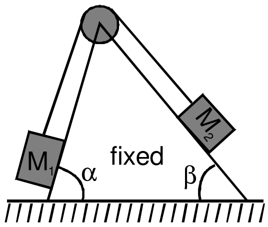
38. The pulley arrangements shown in figure are identical the mass of the rope being negligible. In case I, the mass m is lifted by attaching a mass 2m to the other end of the rope. In case II, the mass m is lifted by pulling the other end of the rope with cosntant downward force F = 2mg, where g is acceleration due to gravity. The acceleration of mass in case I is



(A) zero
(B) more than that in case II
(C) less than that in case II
(D) equal to that in case II

Sol.

39. Two masses M_1 and M_2 are attached to the ends of a light string which passes over a massless pulley attached to the top of a double inclined smooth plane of angles of inclination α and β. The tension in the string is :

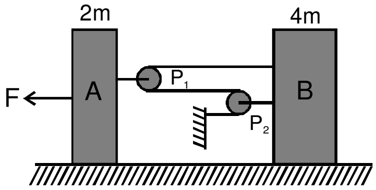


(A) $\frac{M_2(\sin\beta)g}{M_1+M_2}$ (B) $\frac{M_1(\sin\alpha)g}{M_1+M_2}$

(C) $\frac{M_1M_2(\sin\beta+\sin\alpha)g}{M_1+M_2}$ (D) zero

Sol.

40. Calculate the acceleration of the block B in the above figure, assuming the surfaces and the pulleys P_1 and P_2 are all smooth and pulleys and string and light

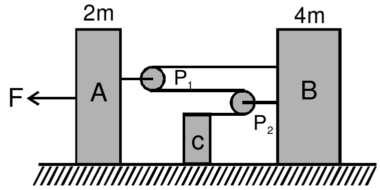


(A) a = $\frac{3F}{17m}$ m/s^2 (B) a = $\frac{2F}{17m}$ m/s^2

(C) a = $\frac{3F}{15m}$ m/s^2 (D) a = $\frac{3F}{12m}$ m/s^2

Sol.

41. In previous Question surface is replaced by block C of mass m as shown in figure. Find the acceleration of block B.

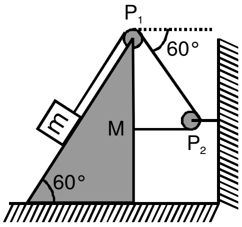


(A) a = $\frac{3F}{20m}$ m/s^2 (B) a = $\frac{3F}{21m}$ m/s^2

(C) a = $\frac{2F}{21m}$ m/s^2 (D) a = $\frac{3F}{18m}$ m/s^2

Sol.

42. In the arrangement shown in the fig, the block of mass m = 2 kg lies on the wedge on mass M = 8 kg. Find the initial acceleration of the wedge if the surfaces are smooth and pulley & strings are massless.

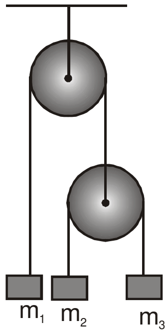


(A) $a = \frac{30\sqrt{3}}{23}$ m/s² (B) $a = \frac{20\sqrt{3}}{23}$ m/s²

(C) $a = \frac{30\sqrt{2}}{23}$ m/s² (D) none of these

Sol.

43. In the arrangement shown in figure, pulleys are massless and frictionless and threads are inextensible. The Block of mass m_1 will remain at rest, if

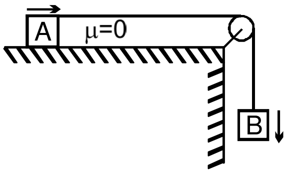


(A) $\frac{1}{m_1} = \frac{1}{m_2} + \frac{1}{m_3}$ (B) $m_1 = m_2 + m_3$

(C) $\frac{4}{m_1} = \frac{1}{m_2} + \frac{1}{m_3}$ (D) $\frac{1}{m_3} = \frac{2}{m_2} + \frac{3}{m_1}$

Sol.

44. 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)



(A) mg (B) mg/2 (C) mg/3 (D) mg/4

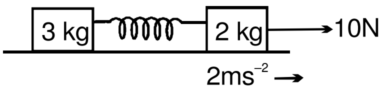
Sol.

45. A monkey of mass 20 kg is holding a vertical rope. The rope can break when a mass of 25 kg is suspended from it. What is the maximum acceleration with which the monkey can climb up along the rope?

(A) 7 ms^{-2} (B) 10 ms^{-2} (C) 5 ms^{-2} (D) 2.5 ms^{-2}

Sol.

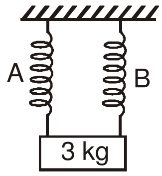
46. Find the acceleration of 3 kg mass when acceleration of 2 kg mass is 2 ms^{-2} as shown in figure.



(A) 3 ms^{-2} (B) 2 ms^{-2} (C) 0.5 ms^{-2} (D) zero

Sol.

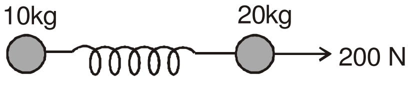
47. Block of 3 kg is initially in equilibrium and is hanging by two identical springs A and B as shown in figures. If spring A is cut from lower point at t = 0 then, find acceleration of block in ms^{-2} at t = 0.



(A) 5 (B) 10 (C) 15 (D) 0

Sol.

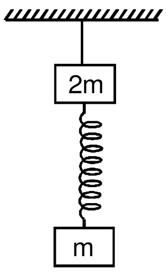
48. Two masses of 10 kg and 20 kg respectively are connected by a massless spring as shown in figure. A force of 200 N acts on the 20 kg mass at the instant when the 10 kg mass has an acceleration of 12 ms^{-2} towards right, the aceleration of the 20 kg mass is :



(A) 2 ms^{-2} (B) 4 ms^{-2} (C) 10 ms^{-2} (D) 20 ms^{-2}

Sol.

49. Two blocks are connected by a spring. The combination is suspended, at rest, from a string attatched 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 ?



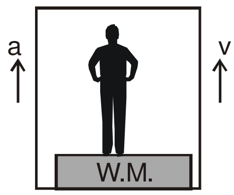
(A) 0 (B) 3g/2 (C) g (D) 2g

Sol.

50. A man of mass 60 kg is standing on a weighing machine placed in a lift moving with velocity 'v' and acceleration 'a' as shown in figure. Calculate the reading of weighing machine in following situation:

($g = 10\ m/s^2$)

(i) a = 0, v = 0
(A) 600 N (B) 500 N (C) 450 N (D) 700 N
(ii) a = 0, v = 2m/s
(A) 600 N (B) 500 N (C) 450 N (D) 700 N
(iii) a = 0, v = −2m/s
(A) 450 N (B) 500 N (C) 600 N (D) 700 N



(iv) $a = 2m/s^2$, v = 0
(A) 600 N (B) 500 N (C) 450 N (D) 720 N
(v) $a = -2m/s^2$ v = 0
(A) 600 N (B) 480 N (C) 450 N (D) 700 N
(vi) $a = 2m/s^2$, v = 2m/s
(A) 600 N (B) 480 N (C) 450 N (D) 720 N
(vii) $a = 2\ m/s^2$, v = −2m/s
(A) 600 N (B) 720 N (C) 450 N (D) 700 N
(viii) $a = -2m/s^2$ v = −2 m/s
(A) 600 N (B) 480 N (C) 450 N (D) 700 N

Sol.

51. What will be the reading of spring balance in the figure shown in following situations. ($g = 10\ m/s^2$)

(i) a = 0, v = 0

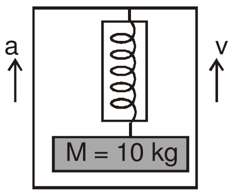
(A) 100 N (B) 80 N (C) 120 N (D) 150 N

(ii) a = 0, v = 2 m/s

(A) 100 N (B) 80 N (C) 120 N (D) 150 N

(iii) a = 0, v = – 2m/s

(A) 100 N (B) 80 N (C) 120 N (D) 150 N



(iv) $a = 2\ m/s^2$, v = 0

(A) 100 N (B) 80 N (C) 120 N (D) 150 N

(v) $a = -2 m/s^2$, v = 0

(A) 100 N (B) 80 N (C) 120 N (D) 150 N

(vi) $a = 2\ m/s^2$, v = 2 m/s

(A) 100 N (B) 80 N (C) 120 N (D) 150 N

(vii) $a = 2\ m/s^2$, v = –2m/s

(A) 100 N (B) 80 N (C) 120 N (D) 150 N

(viii) $a = -2\ m/s^2$, v = – 2 m/s

(A) 100 N (B) 80 N (C) 120 N (D) 150 N

Sol.

Question No. 52 to 54 (3 questions)

An object of mass 2 kg is placed at rest in a frame (S_1) moving with velocity $10\hat{i} + 5\hat{j}$ m/s and having acceleration $5\hat{i} + 10\hat{j}\, m/s^2$. The object is also seen by an observer standing in a frame (S_2) moving with velocity $5\hat{i} + 10\hat{j}\, m/s$

52. Calculate 'Pseudo force' acting on object. Which frame is responsible for this force.

(A) $F = -10\ \hat{i}\ - 20\hat{j}$ due to acceleration of frame S_1

(B) $F = -20\ \hat{i}\ - 20\hat{j}$ due to acceleration of frame S_1

(C) $F = -10\ \hat{i}\ - 30\hat{j}$ due to acceleration of frame S_1

(D) none of these

Sol.

53. Calculate net force acting on object with respect to S_2 frame.

(A) F = $20\hat{i}+20\hat{j}$ (B) F = $10\hat{i}+20\hat{j}$

(C) F = $5\hat{i}+20\hat{j}$ (D) F = $10\hat{i}+5\hat{j}$

Sol.

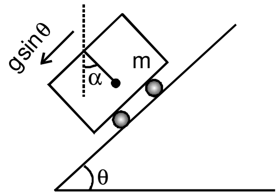
54. Calculate net force acting on object with respect of S_1 frame.

(A) 0 (B) 1

(C) 2 (D) none of these

Sol.

55. A trolley is accelerating down an incline of angle θ with acceleration gsinθ. Which of the following is correct. (α is the constant angle made by the string with vertical)



(A) α = θ

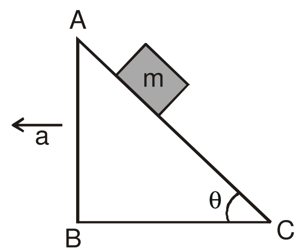
(B) α = 0º

(C) Tension in the string, T = mg

(D) Tension in the string, T = mg sec θ

Sol.

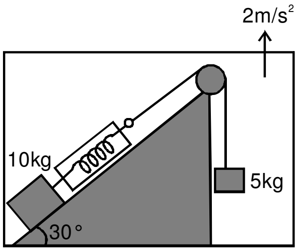
56. A block of mass m resting on a wedge of angle θ as shown in the figure. The wedge is given an acceleration a. What is the minimum value of a so that the mass m falls freely ?



(A) g (B) g cos θ (C) g cot θ (D) g tan θ

Sol.

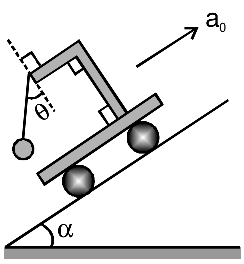
57. In the figure the reading of the spring balanced will be : [g = 10 m/s²]



(A) 50 N (B) 40 N (C) 60 N (D) 70 N

Sol.

58. A pendulum of mass m hangs from a support fixed to a trolley. The direction of the string when the trolley rolls up of plane of inclination α with acceleration a_0 is (String and bob remain fixed with respect to trolley)



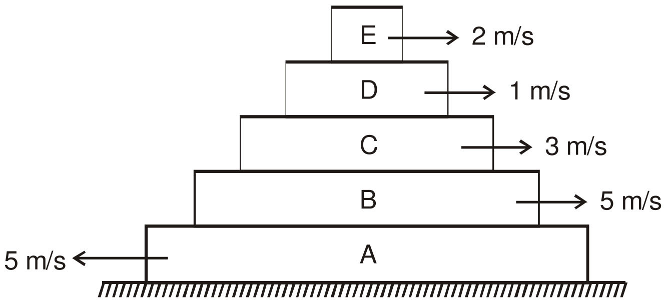
(A) $\theta = \tan^{-1}\alpha$ (B) $\theta = \tan^{-1}\left(\frac{a_0}{g}\right)$

(C) $\theta = \tan^{-1}\left(\frac{g}{a_0}\right)$ (D) $\theta = \tan^{-1}\left(\frac{a_0 + g\sin\alpha}{g\cos\alpha}\right)$

Sol.

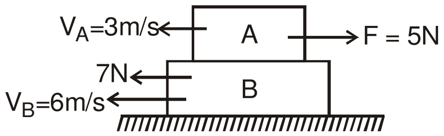
(B) FRICTION

59. 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).



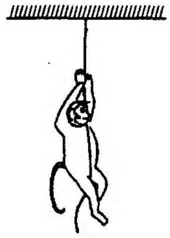
Sol.

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



Sol.

61. 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.

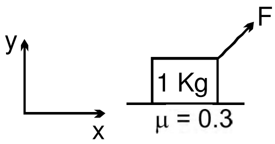


(A) Upward, F = m(g + a)
(B) downward, F = m(g + a)
(C) Upward, F = mg
(D) downward, F = mg
Sol.

62. A body is placed on a rough inclined plane of inclination θ. As the angle θ is increased from 0º to 90º 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

Sol.

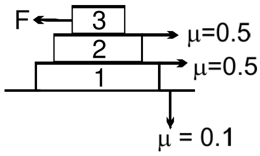
63. A force $\vec{F} = \hat{i} + 4\hat{j}$ acts on block shown. The force of friction acting on the block is



(A) $-\hat{i}$ (B) $-1.8\hat{i}$ (C) $-2.4\hat{i}$ (D) $-3\hat{i}$

Sol.

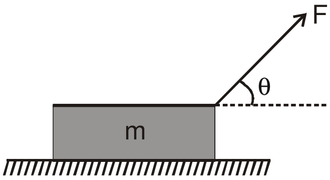
64. If force F is increasing with time and at t=0, F=0 where will slipping first start ?



(A) between 3 kg and 2 kg
(B) between 2 kg and 1 kg
(C) between 1 kg and ground
(D) both (A) and (B)

Sol.

65. A wooden block of mass m resting on a rough horizontal table (coefficient of friction = μ) is pulled by a force F as shown in figure. The acceleration of the block moving horizontally is :

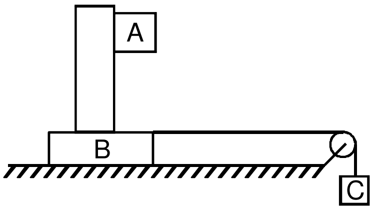


(A) $\frac{F\cos\theta}{m}$ (B) $\frac{\mu F\sin\theta}{M}$

(C) $\frac{F}{m}(\cos\theta + \mu\sin\theta) - \mu g$ (D) none

Sol.

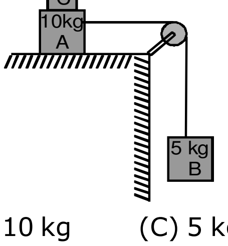
66. In the arrangement shown in the figure, mass of the block B and A is 2m and m respectively. Surface between B and floor is smooth. The block B is connected to the block C by means of a string pulley system. If the whole system is released, then find the minimum value of mass of block C so that block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



(A) $\frac{m}{\mu}$ (B) $\frac{2m+1}{\mu+1}$ (C) $\frac{3m}{\mu-1}$ (D) $\frac{6m}{\mu+1}$

Sol.

67. Two masses A and B of 10 kg and 5 kg respectively are connected with a string passing over a fricionless pulley fixed at the corner of a table as shown in figure. The coefficient of friction of A with the table is 0.2. The minimum mass of C that may be placed on A to prevent if from moving is equal to :



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

Sol.

68. If the coefficient of friction between an insect and bowl is μ and the radius of the bowl, is r, the maximum height to which the insect can crawl in the bowl is :

(A) $\frac{r}{\sqrt{1+\mu^2}}$ (B) $r\left[1-\frac{1}{\sqrt{1+\mu^2}}\right]$

(C) $r\sqrt{1+\mu^2}$ (D) $r\sqrt{1+\mu^2}-1$

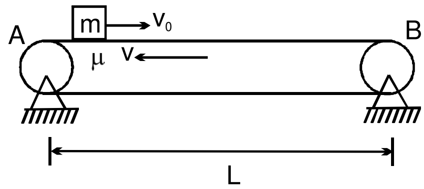
Sol.

69. A body of mass m moves with a velocity v on a surface whose friction coefficient is μ. If the body covers a distance s then v will be :

(A) $\sqrt{2\mu gs}$ (B) $\sqrt{\mu gs}$ (C) $\sqrt{\mu gs/2}$ (D) $\sqrt{3\mu gs}$

Sol.

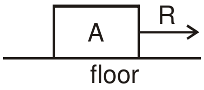
70. With what minimum velocity should block be projected from left end A towards end B such that it reaches the other end B of conveyer belt moving with constant velocity v. Friction coefficient between block and belt is μ.

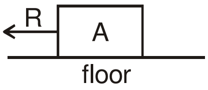


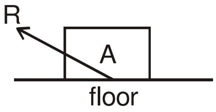
(A) $\sqrt{\mu gL}$ (B) $\sqrt{2\mu gL}$ (C) $\sqrt{3\mu gL}$ (D) $2\sqrt{\mu gL}$

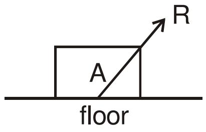
Sol.

71. A box 'A' is lying on the horizontal floor of the compartment of a train running along horizontal rails from left to right. At time 't', it decelerates. Then the reaction R by the floor on the box is given best by

(A) 

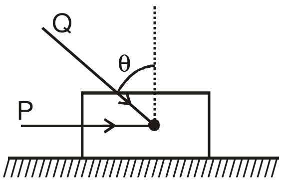
(B) 

(C) 

(D) 

Sol.

72. 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) $\frac{P\sin\theta - Q}{mg - Q\cos\theta}$

Sol.

73. 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 the distance covered by the mass before it stops is :

(A) $\frac{2}{\mu_0}\tan\theta$ (B) $\frac{4}{\mu_0}\tan\theta$ (C) $\frac{1}{2\mu_0}\tan\theta$ (D) $\frac{1}{\mu_0}\tan\theta$

Sol.

74. In the above question the speed of the mass when travelled half the maximum distance is

(A) $\sqrt{\dfrac{g\tan\theta\sin\theta}{\mu_0}}$ (B) $\sqrt{\dfrac{g\tan\theta\sin\theta}{2\mu_0}}$

(C) $\sqrt{\dfrac{g\tan\theta\sin\theta}{8\mu_0}}$ (D) none of these

Sol.

75. For the equilibrium of a body on an inclined plane of inclination 45º. The coefficient of static friction will be

(A) greater than one (B) less than one
(C) zero (D) less than zero

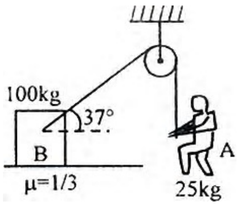
Sol.

76. A body is moving down a long inclined plane of slope 37º. The coefficient of friction between the body and plane varies as μ = 0.3 x, where x is distance travelled down the plane. The body will have maximum speed. (sin 37º = $\frac{3}{5}$ and g = 10 m/s^2)

(A) at x = 1.16 m (B) at x = 2m
(C) at bottom of plane (D) at x = 2.5 m

Sol.

77. 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 climbs on rope without making block move is



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

Sol.

78. Starting from rest a body slides down a 45° 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

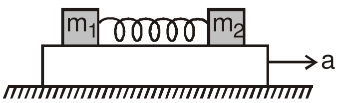
Sol.

79. A block of mass 5 kg and surface area 2 m^2 just begins to slide down an inclined plane when the angle of inclination is 30°. Keeping mass same, the surface area of the block is doubled. The angle at which this starts sliding down is :

(A) 30° (B) 60° (C) 15° (D) none

Sol.

80. Two blocks of masses m_1 and m_2 are connected with a massless unstretched spring and placed over a plank moving with an acceleration 'a' as shown in figure. the coefficient of friction between the blocks and platform is μ.



(A) spring will be stretched if $a > \mu g$

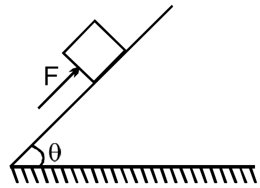
(B) spring will be compressed if $a \le \mu g$

(C) spring will neither be compressed nor be stretched for $a \le \mu g$

(D) spring will be in its natural length under all conditions.

Sol.

81. A block placed on a rough inclined plane of inclination (θ = 30º) can just be pushed upwards by applying a force "F" as shown. If the angle of inclination of the inclined plane is increased to (θ = 60º), 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

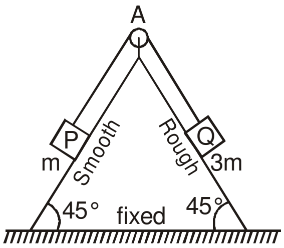


(A) $\frac{\sqrt{3}+1}{\sqrt{3}-1}$ (B) $\frac{2\sqrt{3}-1}{\sqrt{3}+1}$

(C) $\frac{\sqrt{3}-1}{\sqrt{3}+1}$ (D) none of these

Sol.

82. A fixed wedge with both surface inclined at 45° 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) $\frac{mg}{4}$

Sol.

(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) $\frac{2}{5}$

Sol.

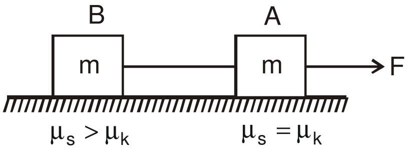
(c) In the above question the magnitude and direction of the force exerted by the string on the pulley is :

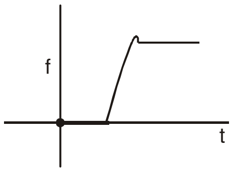
(A) $\frac{6mg}{5}$ downward (B) $\frac{6mg}{5}$ upward

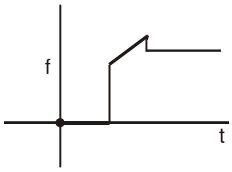
(C) $\frac{mg}{5}$ downward (D) $\frac{mg}{4}$ downward

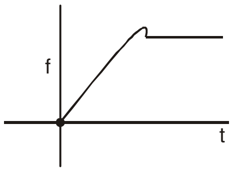
Sol.

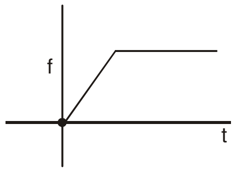
83. A force F = t is applied to block A as shown in figure. The force is applied at t = 0 seconds when the system was at rest and string is just straight without tension. Which of the following graphs gives the friction force between B and horizontal surface as a function a time 't'.



(A)


(B)


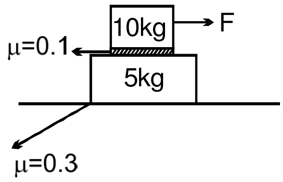
(C)


(D)


Sol.

For Q.84. to Q.88 refer given figure (5 questions)

84. When F = 2N, the frictional force between 5 kg block and ground is



(A) 2N (B) 0 (C) 8 N (D) 10 N

Sol.

85. When F = 2N, the frictional force between 10 kg block and 5 kg block is

(A) 2N (B) 15N (C) 10N (D) None

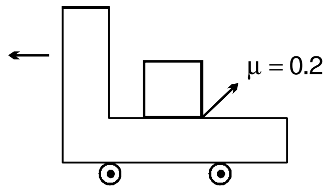
Sol.

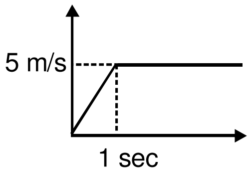
86. The maximum "F" which will not cause motion of any of the blocks
(A) 10N (B) 15N
(C) data insufficient (D) None
Sol.

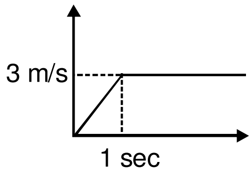
87. The maximum acceleration of 5 kg block
(A) 1 m/s^2 (B) 3 m/s^2 (C) 0 (D) None
Sol.

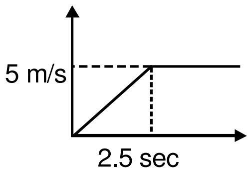
88. The acceleration of 10 kg block when F = 30 N
(A) 2 m/s^2 (B) 3 m/s^2 (C) 1 m/s^2 (D) None
Sol.

89. A truck starting from rest moves with an acceleration of 5 m/s^2 for 1 sec and then moves with constant velocity. The velocity w.r.t. ground v/s time graph for block in truck is (Assume that block does not fall off the truck)



(A) 

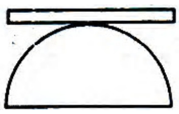
(B) 

(C) 

(D) None of these

Sol.

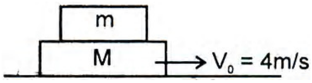
90. A board is balanced on a rough horizontal semicircular log. Equilibrium is obtained with the help of addition of a weight to one of the ends of the board when the board makes an angle θ with the horizontal. Coefficient of friction between the log and the board is



(A) tan θ (B) cos θ (C) cot θ (D) sin θ

Sol.

91. A stationary body of mass m is slowly lowered onto a massive plateform of mass M (M >> m) moving at a speed V_0 = 4 m/s as shown in fig. How far will the body slide along the platform (μ = 0.2 and g = 10 m/s^2) ?



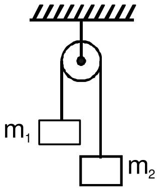
(A) 4 m (B) 6 m (C) 12 m (D) 8 m

Sol.

Exercise - II (One or more than one option is correct)

(A) N. L. M

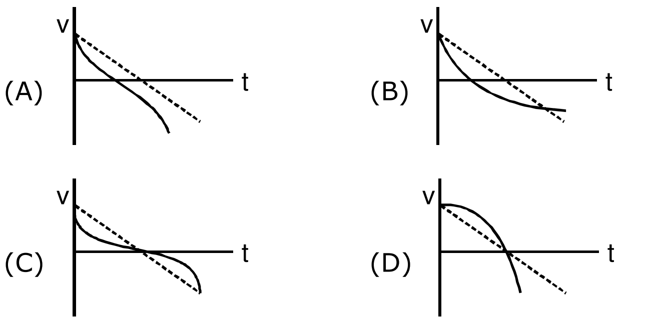
1. A student calculates the acceleration of m_1 in figure shown as $a_1 = \frac{(m_1 - m_2)g}{m_1 + m_2}$. Which assumption is not required to do this calculation.



(A) pulley is frictionless (B) string is massless
(C) pulley is massless (D) string is inextensible

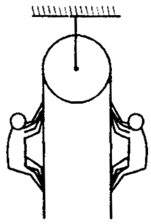
Sol.

2. Which graph shows best the velocity-time graph for an object launched vertically into the air when air resistance is given by |D| = bv? The dashed line shows the velocity graph if there were no air resistance.



Sol.

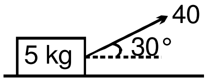
3. Two men of unequal masses hold on to the two sections of a light rope passing over a smooth light pulley. Which of the following are possible?



(A) The lighter man is stationary while the heavier man slides with some acceleration
(B) The heavier man is stationary while the lighter man climbs with some acceleration
(C) The two men slide with the same acceleration in the same direction
(D) The two men move with accelerations of the same magnitude in opposite directions

Sol.

4. Adjoining figure shows a force of 40 N acting at 30° to the horizontal on a body of mass 5 kg resting on a smooth horizontal surface. Assuming that the acceleration of free-fall is 10 ms^{-2}, which of the following statements A, B, C, D, E is (are) correct?



[1] The horizontal force acting on the body is 20 N
[2] The weight of the 5 kg mass acts vertically downwards
[3] The net vertical force acting on the body is 30 N

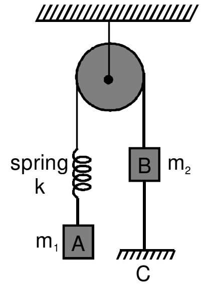
(A) 1, 2, 3 (B) 1, 2 (C) 2 only (D) 1 only

Sol.

5. For ordinary terrestrial experiments, which of the following observers below are inertial.
(A) a child revolving in a "giant wheel".
(B) a driver in a sports car moving with a constant high speed of 200 km/h on a straight road.
(C) the pilot of an aeroplane which is taking off.
(D) a cyclist negotiating a sharp turn.

Sol.

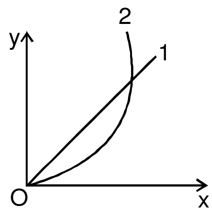
6. In the system shown in the figure $m_1 > m_2$. System is held at rest by thread BC. Just after the thread BC is burnt :



(A) acceleration of m_2 will be upwards
(B) magnitude of acceleration of both blocks will be equal to $\left(\frac{m_1 - m_2}{m_1 + m_2}\right)g$
(C) acceleration of m_1 will be equal to zero
(D) magnitude of acceleration of two blocks will be non-zero and unequal.

Sol.

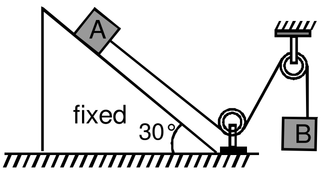
7. A particle is resting on a smooth horizontal floor. At t = 0, a horizontal force starts acting on it. Magnitude of the force increases with time according to law F = α.t, where α is a constant. For the figure shown which of the following statements is/are correct ?



(A) Curve 1 shows acceleration against time
(B) Curve 2 shows velocity against time
(C) Curve 2 shows velocity against acceleration
(D) none of these

Sol.

8. Two blocks A and B of equal mass m are connected through a massless string and arranged as shown in figure. Friction is absent everywhere. When the system is released from rest.



(A) tension in string is $\frac{mg}{2}$

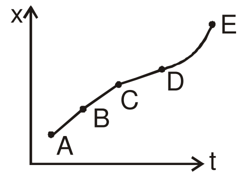
(B) tension in string is $\frac{mg}{4}$

(C) acceleation of A is g/2

(D) acceleration of A is $\frac{3}{4}g$

Sol.

9. Figure shows the displacement of a particle going along the x-axis as a funtion of time :



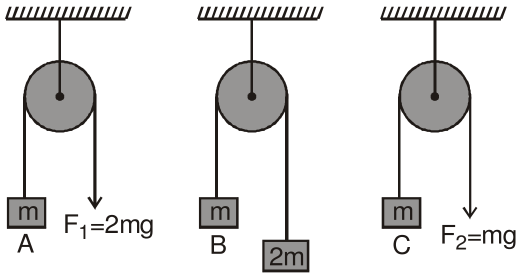
(A) the force acting on the particle is zero in the region AB
(B) the force acting on the particle is zero in the region BC
(C) the force acting o the particle is zero in the region CD
(D) the force is zero no where.

Sol.

10. A force of magnitude F_1 acts on a particle so as to accelerate it from rest to a velocity v. The force F_1 is then replaced by another force of magnitude F_2 which decelerates it to rest.
(A) F_1 must be the equal to F_2
(B) F_1 may be equal to F_2
(C) F_1 must be unequal to F_2
(D) None of these

Sol.

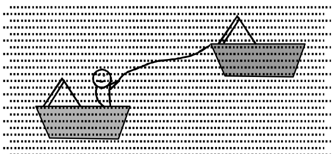
11. In the figure, the blocks A, B and c of mass m each have acceleration a_1. a_2 and a_3 respectively. F_1 and F_2 are external forces of magnitudes 2 mg and mg respectively.



(A) $a_1 = a_2 = a_3$ (B) $a_1 > a_2 > a_3$
(C) $a_1 = a_2$, $a_2 > a_3$ (D) $a_1 > a_2$, $a_2 = a_3$

Sol.

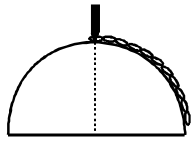
12. A rope is stretched between two boats at rest. A sailor in the first boat pulls the rope with a constant force of 100 N. First boat with the sailor has a mas of 250 kg whereas mass of second boat is double of that mass. If the initial distance between the boats was 100 m, the time taken for two boats to meet each other is -



(A) 13.8 s (B) 18.3 s (C) 3.18 s (D) 31.8 s

Sol.

13. A chain of length l is placed on a smooth spherical surface of radius r with one of its ends fixed at the top of the surface. Length of chain is assumed to be $l < \frac{\pi r}{2}$. Acceleration of each element of chain when upper end is released is -



(A) $\frac{\ell g}{r}\left(1-\cos\frac{r}{\ell}\right)$ (B) $\frac{rg}{\ell}\left(1-\cos\frac{\ell}{r}\right)$

(C) $\frac{\ell g}{r}\left(1-\sin\frac{\ell}{r}\right)$ (D) $\frac{rg}{\ell}\left(1-\sin\frac{r}{\ell}\right)$

Sol.

14. Five persons A, B, C, D & E are pulling a cart of mass 100 kg on a smooth surface and cart is moving with acceleration 3 m/s^2 in east direction. When person 'A' stops pulling, it moves with acceleration 1 m/s^2 in the west direction. When person 'B' stops pulling, it moves with acceleration 24 m/s^2 in the north direction. The magnitude of acceleration of the cart when only A & B pull the cart keeping their directions same as the old directions, is :

(A) 26 m/s^2 (B) $3\sqrt{71}\,m/s^2$

(C) 25 m/s^2 (D) 30 m/s^2

Sol.

(B) FRICTION

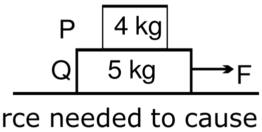
15. A block of mass 2.5 kg is kept on a rough horizontal surface. It is found that the block does not slide if a horizontal force less than 15 N is applied to it. Also it is if found that it takes 5 second to slide throughout the first 10 m if a horizontal force of 15 N is applied and the block is gently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

(A) $\mu_s = 0.60$ (B) $\mu_k = 0.52$

(C) $\mu_k = 0.60$ (D) $\mu_s = 0.52$

Sol.

16. The coefficient of friction between 4 kg and 5 kg blocks is 0.2 and between 5 kg block and ground is 0.1 respectively. Choose the correct statements



(A) Minimum force needed to cause system to move is 17N

(B) When force is 4N static friction at all surfaces is 4 N to keep system at rest.

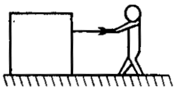
(C) Maximum acceleration of 4 kg block is 2 m/s^2

(D) Slipping between 4 kg and 5 kg blocks start when F is 17 N

Sol.

17. In a tug-of-war contest, two men pull on a horizontal rope from opposite sides. The winner will be the man who
(A) exerts greater force on the rope
(B) exerts greater force on the ground
(C) exerts a force on the rope which is greater than the tension in the rope
(D) makes a smaller angle with the vertical
Sol.

18. A man pulls a block heavier than himself with a light horizontal rope. The coefficient of friction is the same between the man and the ground, and between the block and the ground.

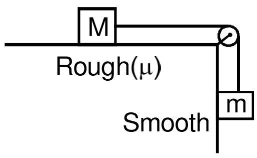


(A) The block will not move unless the man also moves
(B) The man can move even when the block is stationary
(C) If both move, the acceleration of the man is greater than the acceleration of the block
(D) None of the above assertions is correct

Sol.

Question No. 19 to 20 (2 questions)

In figure, two blocks M and m are tied together with an inextensible and light string. The mass M is placed on a rough horizontal surface with coefficient of friction μ and the mass m is hanging vertically against a smooth vertical wall. The pulley is frictionless.



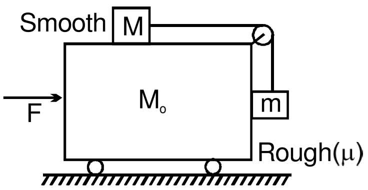
19. Choose the correct statement(s)
(A) The system will accelerate for any value of m
(B) The system will accelerate only when m > M
(C) The system will accelerate only when m > μM
(D) Nothing can be said
Sol.

20. Choose the correct statement(s) related to the tension T in the string
(A) When $m < \mu M$, $T = mg$
(B) When $m < \mu M$, $T = Mg$
(C) When $m > \mu M$, $\mu Mg < T < mg$
(D) When $m > \mu M$, $mg < T < \mu Mg$
Sol.

Sol.

Question No. 21 to 23 (3 questions)

Imagine a situation in which the horizontal surface of block M_0 is smooth and its vertical surface is rough with a coefficient of friction μ



21. Identify the correct statement(s)
(A) If F=0, the blocks cannot remain stationary
(B) For one unique value of F, the blocks M and m remain stationary with respect to M_0
(C) The limiting friction between m and M_0 is independent of F
(D) There exist a value of F at which friction force is equal to zero.

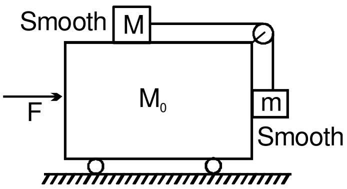
22. In above problem, choose the correct value(s) of F which the blocks M and m remain stationary with respect to M_0

(A) $(M_0 + M + m)\dfrac{g}{\mu}$ (B) $\dfrac{m(M_0 + M + m)g}{M - \mu m}$

(C) $(M_0 + M + m)\dfrac{mg}{M}$ (D) none of these

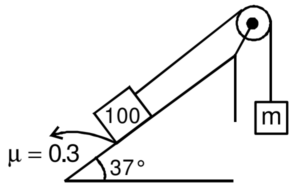
Sol.

23. Consider a special situation in which both the faces of the block M_0 are smooth, as shown in adjoining figure. Mark out the correct statement(s)



(A) If F = 0, the blocks cannot remain stationary
(B) For one unique value of F, the blocks M and m remain stationary with respect to block M_0
(C) There exists a range of F for which blocks M and m remain stationary with respect to block M_0
(D) Since there is no friction, therefore, blocks M and m cannot be in equilibrium with respect to M_0
Sol.

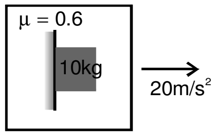
24. The value(s) of mass m for which the 100 kg block remains is static equilibrium is



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

25. 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.
Sol.

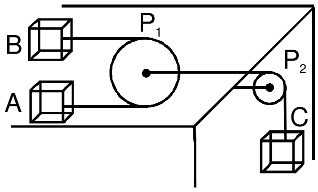
26. Car is accelerating with acceleration = 20 m/s². A box that is placed inside the car, of mass m = 10 kg is put in contact with the vertical wall as shown. The friction coefficient between the box and the wall is μ = 0.6.



(A) The acceleration of the box will be 20 m/sec²
(B) The friction force acting on the box will be 100 N
(C) The contact force between the vertical wall and the box will be $100\sqrt{5}$ N
(D) The net contact force between the vertical wall and the box is only of electromagnetic in nature.
Sol.

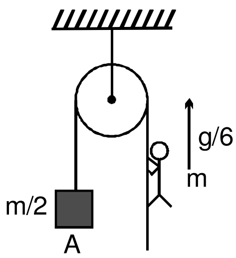
Exercise - III (SUBJECTIVE PROBLEMS)

1. Two masses A and B, lie on a frictionless table. They are attached to either end of a light rope which passes around a horizontal movable pulley of negligible mass. Find the acceleration of each mass $M_A = 1$ kg, $M_B = 2$ kg, $M_C = 4$ kg. The pulley P_2 is vertical.



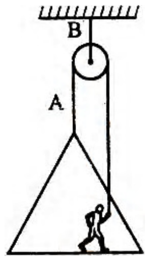
Sol.

2. Block A of mass m/2 is connected to one end of light rope which passes over a pulley as shown in the fig. Man of mass m climbs the other end of rope with a relative acceleration of g/6 with respect to rope find acceleration of block A and tension in the rope.



Sol.

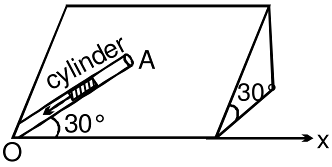
3. To Paint the side of a building, painter normally hoists himself up by pulling on the rope A as in figure. The painter and platform together weigh 200 N . The rope B can withstand 300 N. Find



(a) the maximum acceleration of the painter.
(b) tension in rope A
(i) when painter is at rest
(ii) when painter moves up with an acceleration 2 m/s^2.

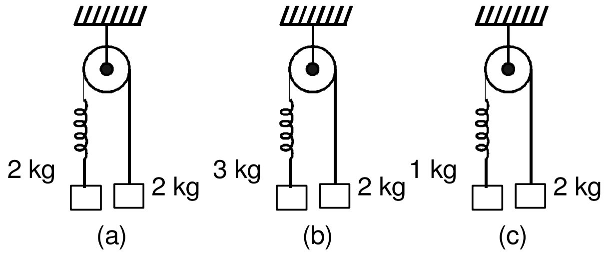
Sol.

4. An inclined plane makes an angle 30º with the horizontal. A groove OA = 5 m cut in the plane makes an angle 30º with OX. A short smooth cylinder is free to slide down the influence of gravity. Find the time taken by the cylinder to due to reach from A to O. ($g = 10\ m/s^2$)



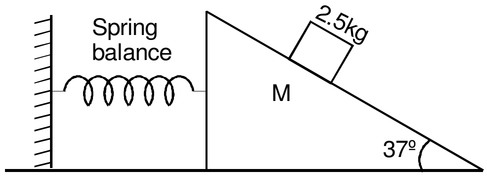
Sol.

5. Same spring is attached with 2 kg, 3 kg and 1 kg blocks in three different cases as shown in figure. If x_1, x_2 and x_3 be the extensions in the spring in these three cases then find the ratio of their extensions.



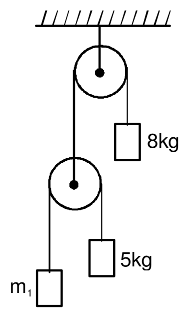
Sol.

6. Find the reading of spring balance as shown in figure. Assume that mass M is in equilibrium. (All surfaces are smooth)



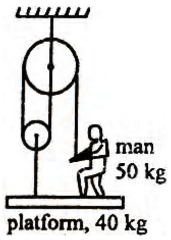
Sol.

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



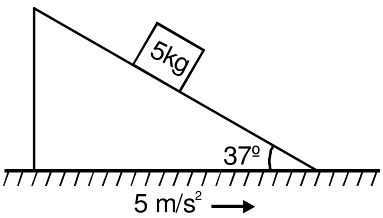
Sol.

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



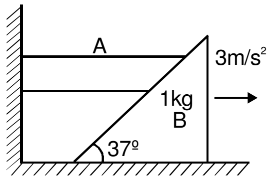
Sol.

9. Inclined plane is moved towards right with an acceleration of $5ms^{-2}$ as shown in figure. Find force in newton which block of mass 5 kg exerts on the incline plane. (All surfaces are smooth)



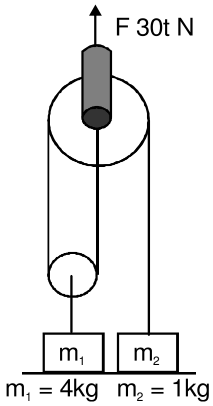
Sol.

10. Find force in newton which mass A exerts on mass B if B is moving towards right with $3\ ms^{-2}$. Also find mass of A. (All surfaces are smooth)



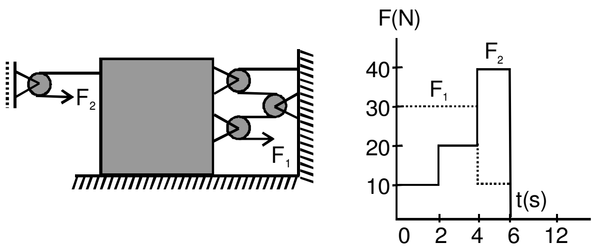
Sol.

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



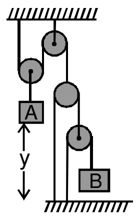
Sol.

12. The 40 kg block is moving to the right with a speed of 1.5 m/s when it is acted upon by forces F_1 & F_2. These forces vary in the manner shown in the graph. Find the velocity of the block after t = 12 s Neglect friction and masses of the pulleys and cords.



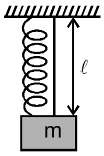
Sol.

13. The vertical displacement of block A in meter is given by $y = t^2/4$ where t is in second. Calculate the downward acceleration a_B of block B.



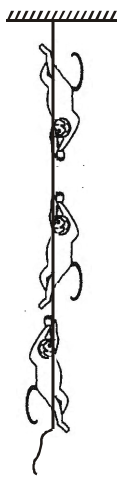
Sol.

14. An object of mass m is suspended in equilibrium using a string of length l and a spring having spring constant K (< 2 mg/l) and unstreched length l/2.



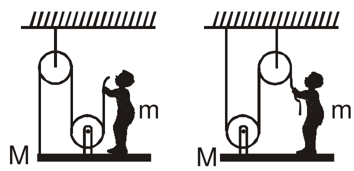
(a) Find the tension in the string
(b) What happens if K > 2 mg / l ?

15. Three monkeys A, B, and C with masses of 10, 15 & 8 kg respectively are climbing up & down the rope suspended from D. at the instant represented, A is descending the rope with an acceleration of 2 m/s^2 & C is pulling himself up with an acceleration of 1.5 m/s^2. Monkeys B is climbing up with a constant speed of 0.8 m/s. Treat the rope and monkeys as a complete system & calculate the tension T in the rope at D. (g = 10 m/s^{-2})



Sol.

16. A person of mass m is standing on a platform of mass M and wants to raise this platform. Massless pulleys are configured in two different ways as shown. We would like to know which configuration makes it easier to raise the platform. Answer the following questions in terms of m, M, a and constant as appropriate. [Note : Assume the rope is also massless and does not stretch.]



Fig(1) Fig(2)

(a) For configuration (1) find the force, F, the person must exert straight up in order to accelerate the platform + person system with an acceleration a. Include a freebody diagram in your solution.
(b) What force does the platform exert on the person when the acceleration of the system is a? Include a freebody diagram in your solution.
(c) If platform is massless, M = 0, and he wants to raise it with a constant velocity find F. Does this configuration offer a mechanical advantage ? (That is, is F < mg ?)
(d) Now repeat the above for configuration (2). First, find the force, F, the person must exert straight down in order to accelerate the platform+ person system with an upward acceleration a. Include a freebody diagram in your solution.
(e) Now, what force does the platform exert on the

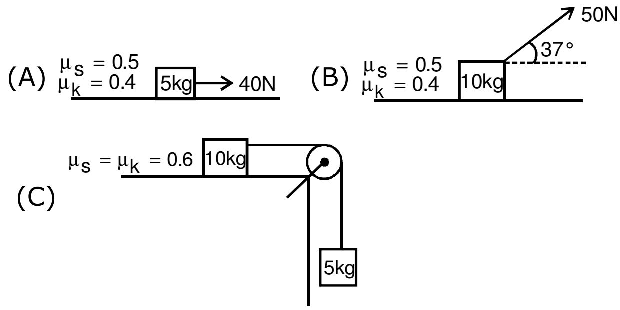
person when the acceleration of the system is a? Include a freebody diagram in your solution.

(f) Again, if the platform is massless, M = 0, and he wants to raise it with a constant velocity find F. Does this configuration offer a mechanical advantage ? (That is, is F < mg?)

Sol.

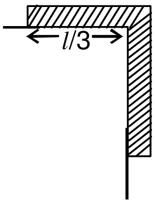
(B) FRICTION

17. Give the acceleration of blocks :



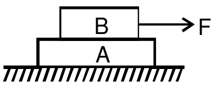
Sol.

18. Determine the coefficient of friction (μ), so that rope of mass m and length l does not slide down.



Sol.

19. 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. Then draw the graph between A and F. [$\mu_k < \mu_s$]



Sol.

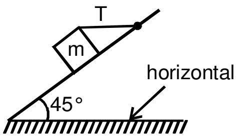
20. A rope so lies on a table that part of it lays over. The rope begins to slide when the length of hanging part is 25 % of entire length. The co-efficient of friction between rope and table is :

Sol.

21. 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 :

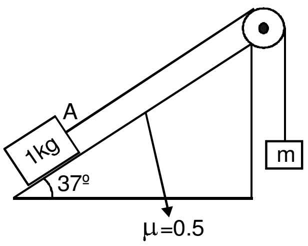
Sol.

22. 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. The coefficient of friction between the surfaces of contact is (g = 10 m/s^2)



Sol.

23. In the figure, what should be mass m so that block A slide up with a constant velocity.

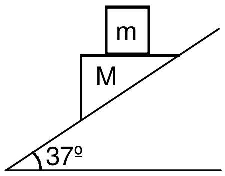


Sol.

24. 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 μ = 0.5. Plank rests on frictionless surface. Find the time when m_1 comes to rest w.r.t. plank.

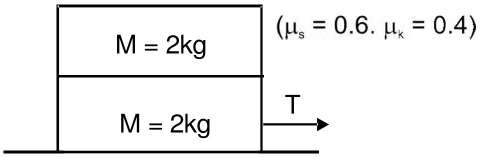
Sol.

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



Sol.

26. The coefficient of static and kinetic friction between the two blocks and also between the lower block and the ground are μ_s = 0.6 and μ_k = 0.4. Find the value of tension T applied on the lower block at which the upper block begins to slip relative to lower block.



Sol.

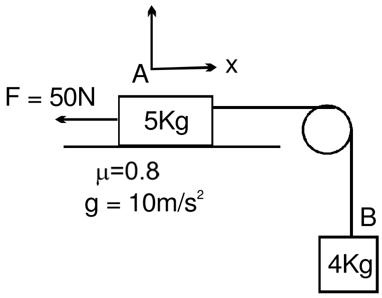
27. A thin rod of length 1 m is fixed in a vertical position inside a train, which is moving horizontally with constant acceleration 4 m/s^2. A bead can slide on the rod, and friction coefficient between them is 1/2. If the bead is released from rest at the top of the rod, find the time when it will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

Sol.

28. A body of mass 2kg rests on a horizontal plane having coefficient of friction μ = 0.5. At t = 0 a horizontal force $\vec{F}$ is applied that varies with time F = 2t. The time constant t_0 at which motion starts and distance moved in t = $2t_0$ second will be _______ and ________ respectively.

Sol.

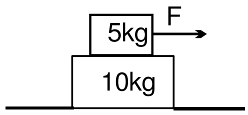
29. Find the acceleration of the blocks and magnitude & direction of frictional force between block A and table, if block A is pulled towards left with a force of 50N.



Sol.

30. A block A of mass 2kg rests on another block B of mass 8kg which rests on a horizontal floor. The coefficient of friction between A and B is 0.2 while that between B and floor is 0.5. When a horizontal force F of 25N is applied on the block B, the force of friction between A and B is _________.

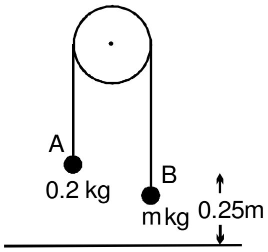
31. Coefficient of friction between 5 kg and 10 kg block is 0.5. If friction between them is 20N. What is the value of force being applied on 5 kg. The floor is frictionless.



Sol.

Exercise - IV (TOUGH SUBJECTIVE PROBLEMS)

1. The diagram shows particles A and B, of masses 0.2 kg and m kg respectively, connected by a light inextensible string which passes over a fixed smooth peg. The system is released from rest, with B at a height of 0.25m above the floor. B descends, hitting the floor 0.5s later. All resistances to motion may be ignored.



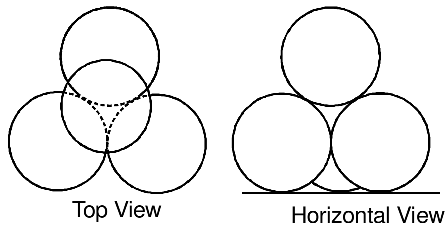
(a) Find the acceleration of B as it descends.

(b) Find the tension in the string while B is descending and find also the value of m.

(c) When B hits the floor it comes to rest immediately, and the string becomes slack. Find the length of time for which B remains at rest on the ground before being jerked into motion again.

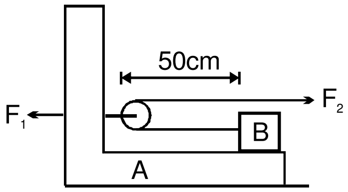
Sol.

2. An ornament for a courtyard at a word's fair is to be made up of four identical, frictionless metal sphere, each weighing $2\sqrt{6}$ Newton. The spheres are to be arranged as shown, with three resting on a horizontal surface and touching each other; the fourth is to rest freely on the other three. The bottom three are kept from separating by spot welds at the points of contact with each other. Allowing for a factor of satety of 3N, how much tension must the spot welds with stand.



Sol.

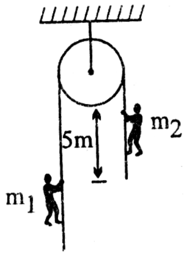
3. A 1kg block 'B' rests as shown on a bracket 'A' of same mass. Constant foroes F_1 = 20 N and F_2 = 8N start to act at time t = 0 when the distance of block B from pulley is 50 cm. Time when block B reaches the pulley is _______.



Sol.

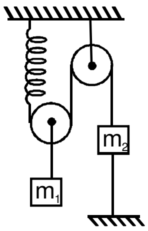
4. Two men of masses m_1 and m_2 hold on the opposite ends of a rope passing over a frictionless pulley. The mass m_1 climbs up the rope with an acceleration of 1.2 m/s^2 relative to the rope. The man m_2 climbs up the rope with an acceleration of 2.0 m/s^2 relative to the

rope. Find the tension in the rope if m_1 = 40 kg and m_2 = 60 kg. Also find the time after which they will be at same horizontal level if they start from rest and are initially separated by 5m.



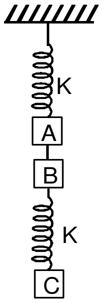
Sol.

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



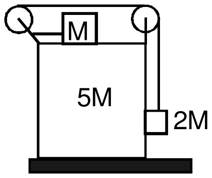
Sol.

6. The system shown adjacent is in equilibrium. Find the acceleration of the blocks A, B & C all of equal masses m at the instant when
(Assume springs to be ideal)
(a) The spring between ceiling & A is cut.



(b) The string (inextensible) between A & B is cut.
(c) The spring between B & C is cut.
Also find the tension in the string when the system is at rest and in the above 3 cases.
Sol.

7. In the system shown. Find the initial acceleration of the wedge of mass 5M. The pulleys are ideal and the cords are inextensible. (there is no friction anywhere).

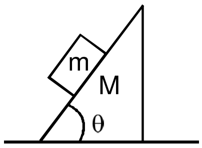


Sol.

8. A smooth right circular cone of semi vertical angle $\alpha = \tan^{-1}(5/12)$ is at rest on a horizontal plane. A rubber ring of mass 2.5 kg which requires a force of 15N for an extension of 10cm is placed on the cone. Find the increase in the radius of the ring in equilibrium.
Sol.

9. A block of mass m lies on wedge of mass M as shown in figure. Answer following parts separately.

(a) With what minimum acceleration must the wedge be moved towards right horizontally so that block m falls freely.



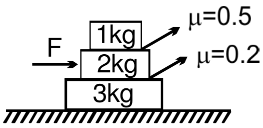
(b) Find the minimum friction coefficient required between wedge M and ground so that it does not move while block m slips down on it.

Sol.

10. A car begins to move at time t = 0 and then accelerates along a straight track with a speed given by $v(t) = 2t^2$ ms^{-1} for $0 \le t \le 2$ After the end of acceleration, the car continues to move at a constant speed. A small block initially at rest on the floor of the car begins to slip at t = 1sec. and stops slipping at t = 3sec. Find the coefficient of static and kinetic friction between the block and the floor.

Sol.

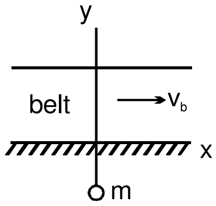
11. In the figure shown,
(i) For what maximum value of force F can all these blocks move together.
(ii) Find the value of force F at which sliding starts at other rough surfaces



(iii) Find acceleration of all blocks, nature and value of friction force of force F = 18N.

Sol.

12. A particle having a mass m and velocity V_m in the y-direction is projected on to a horizontal belt that is moving with uniform velocity V_b in the x-direction as shown in figure. μ is the coefficient of friction between particle and belt. Assuming that the particle first touches the belt at the origin of the fixed xy coordinate system and remains on the belt, find the coordinates (x, y) of the point where the sliding stops.



Sol.

Exercise - V (JEE-PROBLEMS)

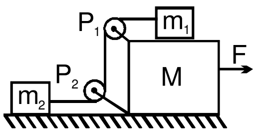
1. A spring of force constant k is cut into two pieces such that one piece is double the length of the other. Then the long piece will have a force constant of

(A) (2/3) k (B) (3/2) k (C) 3k (D) 6K

[JEE 1999]

Sol.

2. In the figure masses m_1, m_2 and M are 20 kg, 5 kg and 50 kg respectively. The co-efficient of friction between M and ground is zero. The co-efficient of friction between m_1 and M and that between m_2 and ground is 0.3. The pulleys and the string are massless. The string is perfectly horizontal between P_1 and m_1 and also between P_2 and m_2. The string is perfectly vertical between P_1 and P_2. An external horizontal force F is applied to the mass M. Take g = 10 m/s^2.



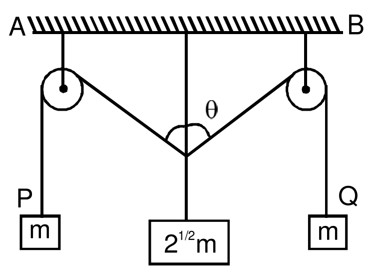
(a) Draw a free - body diagram for mass M, clearly showing all the forces.

(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 $f_1 = 2f_2$. 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. **[JEE 2000]**

Sol.

3. The pulleys and strings shown in the figure are smooth and of negligible mass. For the system to remain in equilibrium, the angle θ should be

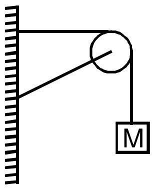
[JEE (Scr) 2001]



(A) 0° (B) 30° (C) 45° (D) 60°

Sol.

4. A string of negligible mass going over a clamped pulley of mass m supports a block of mass M as shown in the figure. The force on the pulley by the clamp is given **[JEE (Scr) 2001]**

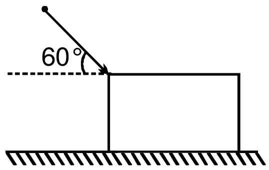


(A) $\sqrt{2}Mg$ (B) $\sqrt{2}mg$

(C) $\sqrt{(M+m)^2+m^2}\,g$ (D) $\sqrt{(M+m)^2+M^2}g$

Sol.

5. A block of mass $\sqrt{3}$ kg is placed on a rough horizontal surface whose coefficient of friction is $1/2\sqrt{3}$ minimum value of force F (shown in figure) for which the block starts to slide on the surface. (g = 10m/s^2)

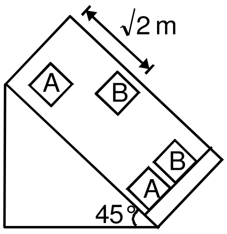


(A) 20 N (B) 20 $\sqrt{3}$ N

(C) $10\sqrt{3}$ N (D) None of these

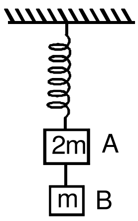
Sol.

6. Two blocks A and B of equal masses are released from an inclined plane of inclination 45° at t = 0. Both the blocks are initially at rest. The coefficient of kientic friction between the block A and the inclined plane is 0.2 while it is 0.3 for block B. Initially, the block A is $\sqrt{2}$ m behind the block B. When and where their front faces will come in line. [Take g = 10m/s^2].



Sol.

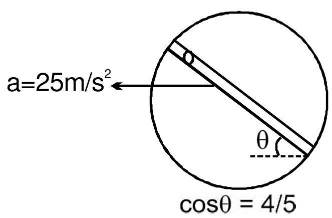
7. Two blocks A and B masses 2m and m, respectively, are connected by a massless and inextensible string. The whole system is suspended by a massless spring as shown in the figure. The magnitudes of acceleration of A and B, immediately after the string is cut, are respectively. **[JEE 2006]**



(A) g, g (B) g, g/2 (C) g/2, g (D) g/2, g/2

Sol.

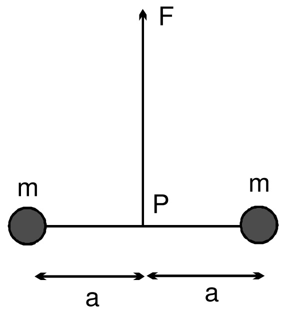
8. A circular disc with a groove along its diameter is placed horizontally. A block of mass 1 kg is placed as shown. The co-efficient of friction between the block and all surfaces of groove in contact is μ = 2/5. The disc has an acceleration of 25 m/s^2. Find the acceleration of the block with respect to disc. **[JEE 2006]**



cosθ = 4/5
sinθ =3/5

Sol.

9. Two particles of mass m each are tied at the ends of a light string of length 2a. The whole system is kept on a frictionless horizontal surface with the string held tight so that each mass is at a distance 'a' from the center P (as shown in the figure). Now, the mid-point of the string is pulled vertically upwards with a small but constant force F. As a result, the particles move towards each other on the surfaces. The magnitude of acceleration, when the separation between them becomes 2x, is **[JEE 2007]**



(A) $\frac{F}{2m}\frac{a}{\sqrt{a^2-x^2}}$ (B) $\frac{F}{2m}\frac{x}{\sqrt{a^2-x^2}}$

(C) $\frac{F}{2m}\frac{x}{a}$ (D) $\frac{F}{2m}\frac{\sqrt{a^2-x^2}}{x}$

Sol.

10. STATEMENT-1

A cloth Covers a table. Some dishes are kept on it. The cloth can be pulled out without dislodging the dishes from the table

because

STATEMENT-2

For every action there is an equal and opposite reaction

(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1

(B) Statement-1 is True, Statement-2 is True; Statement-2 **is NOT** a correct explanation for Statement - 1

(C) Statement-1 is True, Statement-2 is False

(D) Statement-1 is False, Statement-2 is True

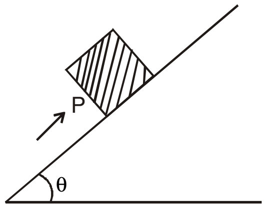
[JEE 2007]

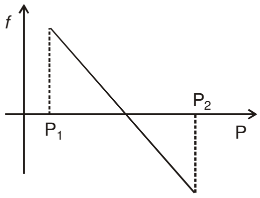
Sol.

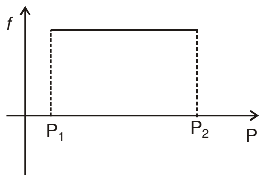
11. STATEMENT-1
It is easier to pull a heavy object than to push it on a level ground.
and
STATEMENT-2
The magnitude of frictional force depends on the nature of the two surfaces in contact.
(A) Statement-1 is true, Statement-2 is true; Statement-2 **is** a correct explanation for Statement-1
(B) Statement-1 is true, statement-2 is true' statement-2 **is NOT** a correct explanation for statement-1
(C) Statement-1 is true, statement-2 is false
(D) Statement-1 is false, statement-2 is true
[JEE 2008]
Sol.

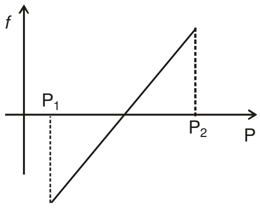
12. A block of base 10 cm × 10 cm and height 15 cm is kept on an inclined plane. The coefficient of friction between them is $\sqrt{3}$. The inclination θ of this inclined plane from the horizontal plane is gradually increased from 0º. Then
(A) at θ = 30º, the block will start sliding down the plane
(B) the block will remain at rest on the plane up to certain θ and then it will topple
(C) at θ = 60º, the block will start sliding down the plane and continue to do so at higher angles
(D) at θ = 60º, the block will start sliding down the plane and on further increasing θ, it will topple at certain θ **[JEE 2009]**
Sol.

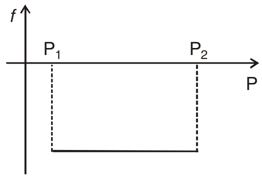
13. A block of mass m is on an inclined plane of angle θ. The coefficient of friction betwen the block and the plane is μ and tan θ > μ. The block is held stationary by applying a force P parallel to the plane. The direction of force pointing up the plane is taken to the positive. As P is varied from P = mg (sin θ – μ cos θ) to P_z = mg (sin θ + μ cos θ), the frictional force f versus P graph will look like



(A)


(B)


(C)


(D)


[JEE 2010]
Sol.

14. A block is moving on an inclined plane making an angle 45º with horizontal and the coefficient of friciton is μ. the force required to just push it up the inclined plane is 3 times the force requried to just prevent it from sliding down. If we define N = 10μ, then N is **[JEE 2011]**

ANSWER KEY — EXERCISE - I

(A) NEWTONS'S LAW OF MOTION

1.	A	**2.**	A	**3.**	A	**4.**	A	**5.**	B	**6.**	A	**7.**	A
8.	D	**9.**	B	**10.**	C	**11.**	A	**12.**	A	**13.**	B	**14.**	A
15.	A	**16.**	D	**17.**	A	**18.**	B	**19.**	B	**20.**	B	**21.**	A
22.	C	**23.**	C	**24.**	A	**25.**	A	**26.**	A	**27.**	B	**28.**	A
29.	B	**30.**	B	**31.**	A	**32.**	B	**33.**	C	**34.**	C	**35.**	B
36.	C	**37.**	C	**38.**	C	**39.**	C	**40.**	A	**41.**	B	**42.**	A
43.	C	**44.**	B	**45.**	D	**46.**	B	**47.**	A	**48.**	B	**49.**	B

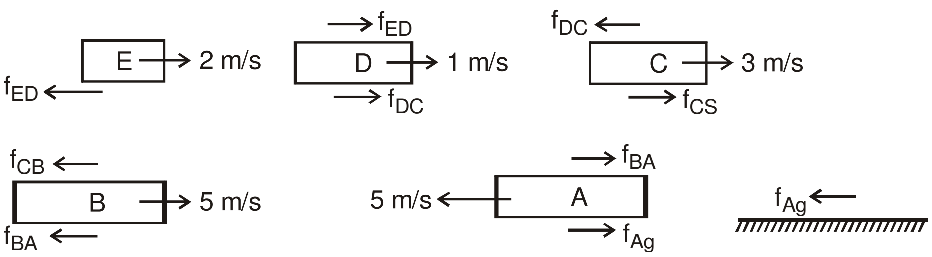
50. (i) A (ii) A (iii) C (iv) D (v) B (vi) D
(vii) B (viii) B

51. (i) A (ii) A (iii) A (iv) C (v) B (vi) C
(vii) C (viii) B

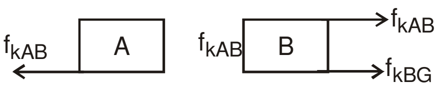
52.	A	**53.**	B	**54.**	A	**55.**	A	**56.**	C	**57.**	C	**58.**	D

(B) FRICTION

59.



60.



61.	A	**62.**	B	**63.**	A	**64.**	C	**65.**	C	**66.**	C	**67.**	A
68.	B	**69.**	A	**70.**	B	**71.**	C	**72.**	A	**73.**	A	**74.**	A
75.	A	**76.**	D	**77.**	B	**78.**	A	**79.**	A	**80.**	D	**81.**	C

82. **(a)** B **(b)** D **(c)** A **83.** A **84.** A **85.** A **86.** A **87.** C

88. A **89.** C **90.** A **91.** A

ANSWER KEY — EXERCISE - II

(A) NEWTONS'S LAW OF MOTION

1.	C	**2.**	B	**3.**	A,B,D	**4.**	C	**5.**	B	**6.**	A,C
7.	A,B,C	**8.**	B,D	**9.**	A,B,C	**10.**	B	**11.**	B	**12.**	B
13.	B	**14.**	C								

(B) FRICTION

15.	A,B	**16.**	C	**17.**	B	**18.**	A,B,C	**19.**	C	**20.**	A,C
21.	A,D	**22.**	B,C	**23.**	A,B	**24.**	B,C	**25.**	B,D	**26.**	A,B,C,D

ANSWER KEY — EXERCISE - III

(A) NEWTON'S LAW OF MOTION

1. $\frac{4g}{5},\frac{2g}{5},\frac{3g}{5}$ **2.** $a=\frac{4g}{9}, T=\frac{13mg}{18}$ **3.** (a) $5m/s^2$, (b) (i) 100N, (ii) 120N

4. 2 sec **5.** $x_2 > x_1 > x_3$ $x_1 : x_2 : x_3$: 15 : 18 : 10 **6.** 12 N **7.** 10/3 kg

8. 300 N **9.** 55 **10.** 5N, 16/31 kg **11.** 2sec **12.** 12 m/s

13. $a_B = 4m/s^2$ (↑) **14.** (a) $T = mg - \frac{kl}{2}$, (b) length of spring will less than 'l' and T = 0 in the string.

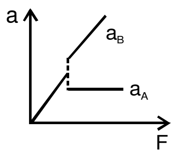
15. 322 N

16. (a) $T=\frac{(m+M)(a+g)}{2}$, (b) N = m(a + g) + T, (c) $T = \frac{mg}{2}$, (d) $T=\frac{(m+M)(a+g)}{3}$

(e) N = m (a + g) – T, (f) $T = \frac{mg}{3}$

(B) FRICTION

17. (A)$4m/s^2$, (B) $1.2\ m/s^2$, (C) 0 **18.** $\mu = 2$

19. 

20. 0.33 **21.** $\frac{1}{3}\mu\pi r^3$ **22.** 1/2 **23.** 1kg

24. 4/3 sec **25.** 3/4 **26.** 40 N **27.** 1/2 sec **28.** 5 sec, 125/6 m

29. $10\hat{i}$ **30.** 0 **31.** 30 N

ANSWER KEY — EXERCISE - IV

1. (a) 2 ms^{-2}, (b) 2.4 N 0.3 (c) 0.2 s **2.** 2 N **3.** 0.5 sec **4.** 556.8 N , 1.47 sec

5. $\left(\frac{m_1 - 2m_2}{2m_2}\right)g$ **6.** (a) $a_A = \frac{3g\downarrow}{2} = a_B \,;\, a_C = 0;\, T = mg/2$ (b) $a_A = 2g\uparrow;\, a_B = 2g\downarrow\,;\, a_C = 0, T = 0$

(c) $a_A = a_B = g/2\uparrow\,;\, T = \frac{3mg}{2};T = 2mg$ **7.** 2g/23 **8.** $\Delta r = \frac{mg\cot\alpha}{4\pi^2 k}$, 1cm

9. (a) a = g cotθ, (b) $\mu_{min} = \frac{m\sin\theta\cos\theta}{m\cos^2\theta + M}$ **10.** $\mu_s = 0.4$, $\mu_k = 0.3$

11. 12 N, 21 N, 4 m/s^2, 2 m/s^2, 4 N, 6 N **12.** $x = \frac{V_b}{2\mu g}\sqrt{V_m^2 + V_b^2}$ $y = \frac{V_m}{2\mu g}\sqrt{V_m^2 + V_b^2}$

ANSWER KEY — EXERCISE - V

1. B **2.** (b) a = 3/5 m/s^2, T = 18 N, F = 60 N **3.** C **4.** D **5.** A
6. 11.313 m **7.** B **8.** 10 m/s^2 **9.** B **10.** B **11.** B
12. B **13.** A **14.** 5N