Yakeen NEET 2.0 (2026)

Physics by Saleem Sir

KPP 25

Laws of Motion

I^st^, II^nd^ and III^rd^ LAWS OF MOTION:

1. An object with mass 500 g moves along x-axis with speed $v = 4\sqrt{x}$ m/s. The force acting on the object is: **[April 7, 2025 (II)]**

(1) 8 N (2) 5 N
(3) 6 N (4) 4 N

2. A body of mass 2 kg moving with velocity of $\vec{v}_{in} = 3\hat{i} + 4\hat{j}\ \text{ms}^{-1}$ enters into a constant force field of 6N directed along positive z-axis. If the body remains in the field for a period of 5/3 seconds, then velocity of the body when it emerges from force field is. **[April 8, 2025 (II)]**

(1) $4\hat{i} + 3\hat{j} + 5\hat{k}$
(2) $3\hat{i} + 4\hat{j} + 5\hat{k}$
(3) $3\hat{i} + 4\hat{j} - 5\hat{k}$
(4) $3\hat{i} + 4\hat{j} + \sqrt{5}\hat{k}$

3. A balloon and its content having mass M is moving up with an acceleration 'a'. The mass that must be released from the content so that the balloon starts moving up with an acceleration '3a' will be (Take 'g' as acceleration due to gravity) **[Jan. 28, 2025 (II)]**

(1) $\dfrac{3Ma}{2a-g}$ (2) $\dfrac{3Ma}{2a+g}$
(3) $\dfrac{2Ma}{3a+g}$ (4) $\dfrac{2Ma}{3a-g}$

4. A player caught a cricket ball of mass 150 g moving at a speed of 20 m/s. If the catching process is completed in 0.1 s, the magnitude of force exerted by the ball on the hand of the player is: **[April 8, 2024 (I)]**

(1) 150 N (2) 3 N
(3) 30 N (4) 300 N

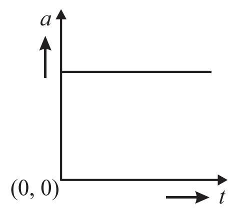
5. A wooden block of mass 5 kg rests on a soft horizontal floor. When an iron cylinder of mass 25 kg is placed on the top of the block, the floor yields and the block and the cylinder together go down with an acceleration of 0.1 ms^{-2}. The action force of the system on the floor is equal to: **[April 5, 2024 (I)]**

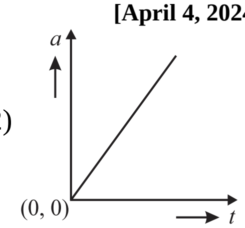
(1) 297 N (2) 294 N
(3) 291 N (4) 196 N

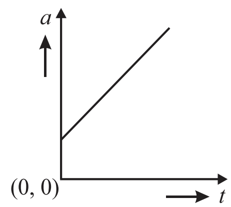
6. A particle moves in $x-y$ plane under the influence of a force $\vec{F}$ such that its linear momentum is $\vec{p}(t) = \hat{\imath}\cos(kt) - \hat{\jmath}\sin(kt)$. If k is constant, the angle between $\vec{F}$ and $\vec{p}$ will be: **[April 5, 2024 (II)]**

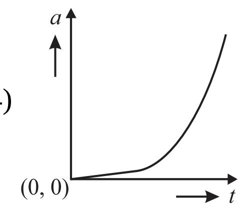
(1) $\pi/2$
(2) $\pi/6$
(3) $\pi/4$
(4) $\pi/3$

7. A wooden block, initially at rest on the ground, is pushed by a force which increases linearly with time t. Which of the following curve best describes acceleration of the block with time: **[April 4, 2024 (I)]**

(1) 

(2) 

(3) 

(4) 

8. A cricket player catches a ball of mass 120 g moving with 25 m/s speed. If the catching process is completed in 0.1 s then the magnitude of force exerted by the ball on the hand of player will be (in SI unit): **[Feb 1, 2024 (II)]**

(1) 30 (2) 24
(3) 12 (4) 25

9. A spherical body of mass 100 g is dropped from a height of 10 m from the ground. After hitting the ground, the body rebounds to a height of 5 m. The impulse of force imparted by the ground to the body is given by: (given, g = 9.8 m/s²) **[Jan 30, 2024 (I)]**

(1) 4.32 kg ms^{-1}
(2) 43.2 kg ms^{-1}
(3) 23.9 kg ms^{-1}
(4) 2.39 kg ms^{-1}

10. A body of mass 1000 kg is moving horizontally with a velocity 6 m/s. If 200 kg extra mass is added, the final velocity (in m/s) is:
[Jan 27, 2024 (I)]

(1) 6 (2) 2
(3) 3 (4) 5

11. A bullet 10 g leaves the barrel of gun with a velocity of 600 m/s. If the barrel of gun is 50 cm long and mass of gun is 3 kg, then value of impulse supplied to the gun will be:
[April 13, 2023 (I)]

(1) 12 Ns
(2) 6 Ns
(3) 36 Ns
(4) 3 Ns

12. Three forces $F_1 = 10$ N, $F_2 = 8$ N, $F_3 = 6$ N are acting on a particle of mass 5 kg. The forces F_2 and F_3 are applied perpendicularly so that particle remains at rest. If the force F_1 is removed, then the acceleration of the particle is:
[April 12, 2023 (I)]

(1) 2 ms^{-2}
(2) 0.5 ms^{-2}
(3) 4.8 ms^{-2}
(4) 7 ms^{-2}

13. An average force of 125 N is applied on a machine gun firing bullets each of mass 10 g at the speed of 250 m/s to keep it in position. The number of bullets fired per second by the machine gun is:
[April 11, 2023 (I)]

(1) 5 (2) 50
(3) 100 (4) 25

14. A body of mass 500 g moves along x-axis such that it's velocity varies with displacement x according to the relation $v = 10\sqrt{x}$ ms^{-1} the force acting on the body is:
[April 11, 2023 (II)]

(1) 166 N
(2) 25 N
(3) 125 N
(4) 5 N

15. At any instant the velocity of a particle of mass 500 g is $(2t\hat{i} + 3t^2\hat{j})ms^{-1}$. If the force acting on the particle at $t = 1$ s is $(\hat{i} + x\hat{j})$N. Then the value of x will be:
[April 8, 2023 (I)]

(1) 3 (2) 4
(3) 6 (4) 2

16. Figure (a), (b), (c) and (d) show variation of force with time.
[Feb. 1, 2023 (II)]

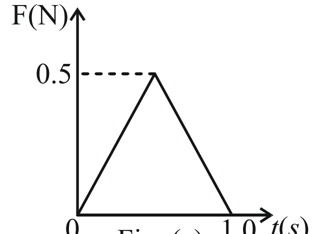
(A)


Fig. (a)

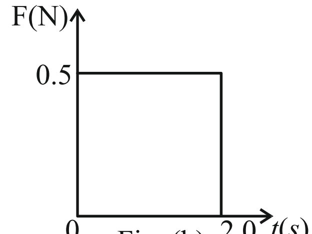
(B)


Fig. (b)

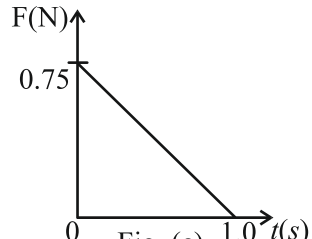
(C)


Fig. (c)

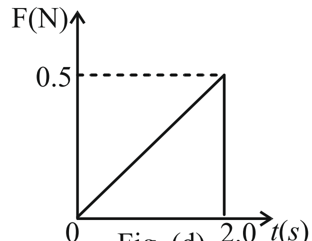
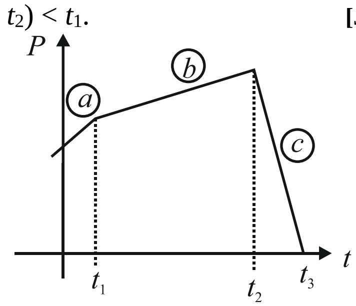
(D)


Fig. (d)

(1) Fig. (A) (2) Fig. (D)
(3) Fig. (C) (4) Fig. (B)

17. The figure represents the momentum time ($p - t$) curve for a particle moving along an axis under the influence of the force. Identify the regions on the graph where the magnitude of the force is maximum and minimum respectively?
If $(t_3 - t_2) < t_1$.
[Jan 30, 2023 (I)]



(1) c and a
(2) b and c
(3) c and b
(4) a and b

18. A machine gun of mass 10 kg fires 20 g bullets at the rate of 180 bullets per minute with a speed of 100 m s^{-1} each. The recoil velocity of the gun is: **[Jan 30, 2023 (II)]**

(1) 0.02 m/s
(2) 2.5 m/s
(3) 1.5 m/s
(4) 0.6 m/s

19. Force acts for 20 s on a body of mass 20 kg, starting from rest, after which the force ceases and then body describes 50 m in the next 10 s. The value of force will be: **[Jan 29, 2023 (II)]**

(1) 40 N (2) 5 N
(3) 20 N (4) 10 N

20. In two different experiments, an object of mass 5 kg moving with a speed of 25^{-1} hits two different walls and comes to rest within (i) 3 second, (ii) 5 second, respectively.
Choose the correct option out of the following: **[Jan 28, 2022 (I)]**

(1) Impulse and average force acting on the object will be same for both the cases.
(2) Impulse will be same for both the cases but the average force will be different.
(3) Average force will be same for both the cases but the impulse will be different.
(4) Average force and impulse will be different for both the cases.

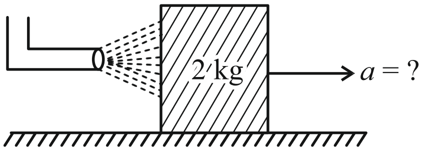
21. A balloon has mass of 10 g in air. The air escapes from the balloon at a uniform rate with velocity 4.5 cm/s. If balloon shrinks in 5 s completely. Then, the average force acting on that balloon will be (in dyne). **[July 28, 2022 (I)]**

(1) 3 (2) 9
(3) 12 (4) 18

22. A ball of mass 0.15 kg hits the wall with its initial speed of 12 ms^{-1} and bounces back without changing its initial speed. If the force applied by the wall on the ball during the con-tact is 100 N. Calculate the time duration of the contact of ball with the wall. **[July 26, 2022 (II)]**

(1) 0.018 s
(2) 0.036 s
(3) 0.009 s
(4) 0.072 s

23. A block of metal weighing 2 kg is resting on a frictionless plane (as shown in figure). It is struck by a jet releasing water at a rate of 1 kgs^{-1} and at a speed of 10 ms^{-1}. Then, the initial acceleration of the block, in ms^{-2}, will be: **[Jan 29, 2023 (I)]**



(1) 3 (2) 6
(3) 5 (4) 4

24. A man of 60 kg is running on the road and suddenly jumps into a stationary trolly car of mass 120 kg. Then the trolly car starts moving with velocity 2 m s^{-1}. The velocity of the running man was ________ ms^{-1}. When he jumps into the car. **[June 28, 2022 (I)]**

25. A block of mass 2 kg moving on a horizontal surface with speed of 4 ms^{-1} enters a rough surface ranging from $x = 0.5$ m to $x = 1.5$ m. The retarding force in this range of rough surface is related to distance by $F = -kx$ where $k = 12$ Nm^{-1}. The speed of the block as it just crosses the rough surface will be: **[June 28, 2022 (II)]**

(1) Zero (2) 1.5 ms^{-1}
(3) 2.0 ms^{-1} (4) 2.5 ms^{-1}

26. A batsman hits back a ball of mass 0.4 kg straight in the direction of the bowler without changing its initial speed of 15 ms^{-1}. The impulse imparted to the ball is ________. **[June 26, 2022 (II)]**

27. A force on an object of mass 100 g is $\left(10\hat{i}+5\hat{j}\right)$N. the position of that object at t = 2s is $\left(a\hat{i}+b\hat{j}\right)$m after starting from rest. The value of a/b will be_______. **[June 26, 2022 (I)]**

28. An object of mass 5 kg is thrown vertically upwards from the ground. The air resistance produces a constant retarding force of 10 N throughout the motion. The ratio of time of ascent to the time of descent will be equal to: [Use $g = 10$ ms^{-2}] **[June 24, 2022 (II)]**

(1) 1 : 1 (2) $\sqrt{2}:\sqrt{3}$
(3) $\sqrt{3}:\sqrt{2}$ (4) 2 : 3

29. The initial mass of a rocket is 1000 kg. Calculate at what rate the fuel should be burnt so that the rocket is given an acceleration of 20 ms^{-2}. The gases come out at a relative speed of 500 ms^{-1} with respect to the rocket : [Use g = 10 m/s^2]

[Aug. 26, 2021 (I)]

(1) 6.0×10^2 kg s^{-1}
(2) 500 kg s^{-1}
(3) 10 kg s^{-1}
(4) 60 kg s^{-1}

30. A particle of mass M originally at rest is subjected to a force whose direction is constant but magnitude varies with time according to the relation

$$F = F_0\left[1 - \left(\frac{t-T}{T}\right)^2\right]$$

Where F_0 and T are constants. The force acts only for the time interval 2T. The velocity v of the particle after time 2T is:

[Aug. 27, 2021 (II)]

(1) $2F_0T/M$ (2) $F_0T/2M$
(3) $4F_0T/3M$ (4) $F_0T/3M$

31. A force $\vec{F} = (40\hat{i} + 10\hat{j})$N acts on a body of mass 5 kg. If the body starts from rest, its position vector $\vec{r}$ at time = 10 s, will be:

[July 25, 2021 (II)]

(1) $(100\hat{i} + 400\hat{j})$m
(2) $(100\hat{i} + 100\hat{j})$m
(3) $(400\hat{i} + 100\hat{j})$m
(4) $(400\hat{i} + 400\hat{j})$m

32. A boy pushes a box of mass 2 kg with a force $\vec{F} = \left(20\hat{i} + 10\hat{j}\right)$N on a frictionless surface. If the box was initially at rest, then ________m is displacement along the x-axis after 10 s.

[Feb. 26, 2021 (I)]

33. A particle moving in the xy plane experiences a velocity dependent force $\vec{F} = k(v_y\hat{i} + v_x\hat{j})$,where v_x and v_y are the x and y components of its velocity $\vec{v}$. If $\vec{a}$ is the acceleration of the particle, then which of the following statements is true for the particle?

[Sep 06, 2020 (II)]

(1) quantity $\vec{v} \times \vec{a}$ is constant in time
(2) $\vec{F}$ arises due to a magnetic field
(3) kinetic energy of particle is constant in time
(4) quantity $\vec{v} \cdot \vec{a}$ is constant in time

34. A spaceship in space sweeps stationary interplanetary dust. As a result, its mass increases at a rate $\frac{dM(t)}{dt} = bv^2(t)$ where $v(t)$ is its instantaneous velocity. The instantaneous acceleration of the satellite is:

[Sep 05, 2020 (II)]

(1) $-bv^3(t)$ (2) $-\frac{bv^3}{M(t)}$
(3) $-\frac{2bv^3}{M(t)}$ (4) $-\frac{bv^3}{2M(t)}$

35. A small ball of mass m is thrown upward with velocity u from the ground. The ball experiences a resistive force mkv^2 where v is its speed. The maximum height attained by the ball is:

[Sep 04, 2020 (II)]

(1) $\frac{1}{2k}\tan^{-1}\frac{ku^2}{g}$ (2) $\frac{1}{k}\ln\left(1+\frac{ku^2}{2g}\right)$
(3) $\frac{1}{k}\tan^{-1}\frac{ku^2}{2g}$ (4) $\frac{1}{2k}\ln\left(1+\frac{ku^2}{g}\right)$

36. A ball is thrown upward with an initial velocity v_0 from the surface of the earth. The motion of the ball is affected by a drag force equal to $m\gamma v^2$ (where m is mass of the ball, v is its instantaneous velocity and γ is a constant). Time taken by the ball to rise to its zenith is: **[10 April 2019 I]**

(1) $\frac{1}{\sqrt{\gamma g}}\tan^{-1}\left(\sqrt{\frac{\gamma}{g}}v_0\right)$

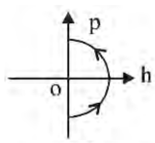
(2) $\frac{1}{\sqrt{\gamma g}}\sin^{-1}\left(\sqrt{\frac{\gamma}{g}}v_0\right)$

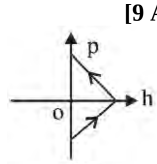
(3) $\frac{1}{\sqrt{\gamma g}}ln\left(1+\sqrt{\frac{\gamma}{g}}v_0\right)$

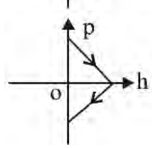
(4) $\frac{1}{\sqrt{2\gamma g}}\tan^{-1}\left(\sqrt{\frac{2\gamma}{g}}v_0\right)$

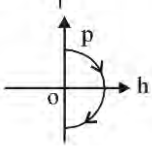
37. A ball is thrown vertically up (taken as + z-axis) from the ground The correct momentum-height (p-h) diagram is:

[9 April 2019 I]

(1) 

(2) 

(3) 

(4) 

38. A particle of mass *m* is moving in a straight line with momentum *p*. Starting at time *t* = 0, a force F = *kt* acts in the same direction on the moving particle during time interval T so that its momentum changes from *p* to 3*p*. Here *k* is a constant. The value of T is:
[11 Jan. 2019 II]

(1) $2\sqrt{\frac{k}{p}}$ (2) $2\sqrt{\frac{p}{k}}$
(3) $\sqrt{\frac{2k}{p}}$ (4) $\sqrt{\frac{2p}{k}}$

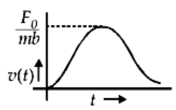
39. A particle of mass m is acted upon by a force F given by the empirical law $F = \frac{R}{t^2} v(t)$. If this law is to be tested experimentally by observing the motion starting from rest, the best way is to plot:
[Online April 10, 2016]

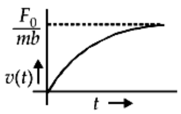
(1) log $v(t)$ against $1/t$
(2) $v(t)$ against t^2
(3) log $v(t)$ against $1/t^2$
(4) log $v(t)$ against t

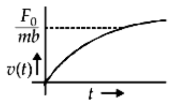
40. A body of mass 5 kg is under the action of a constant force $\vec{F} = F_x\hat{i} + F_y\hat{j}$. Its velocity at $t = 0$ s is $\vec{v} = (6\hat{i} - 2\hat{j})$ m/s, and at $t = 10$ s its velocity is $\vec{v} = +6\hat{j}$ m/s. The force $\vec{F}$ is:
[Online April 11, 2014]

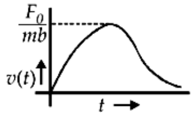
(1) $(-3\hat{j} + 4\hat{j})$N (2) $\left(-\frac{3}{5}\hat{i} + \frac{4}{5}\hat{j}\right)$N
(3) $(3\hat{i} - 4\hat{j})$N (4) $\left(\frac{3}{5}\hat{i} - \frac{4}{5}\hat{j}\right)$N

41. A particle of mass *m* is at rest at the origin at time *t* = 0. It is subjected to a force F(*t*) = $F_0 e^{-bt}$ in the *x* direction. Its speed *v*(*t*) is depicted by which of the following curves?
[2012]

(1) 

(2) 

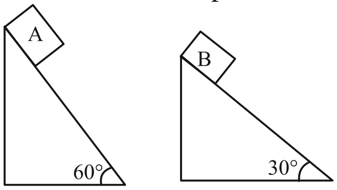
(3) 

(4) 

42. This question has Statement 1 and Statement 2. Of the four choices given after the Statements, choose the one that best describes the two Statements.
Statement 1: If you push on a cart being pulled by a horse so that it does not move, the cart pushes you back with an equal and opposite force.
Statement 2: The cart does not move because the force described in statement 1 cancel each other.
[Online May 26, 2012]

(1) Statement 1 is true, Statement 2 is true, Statement 2 is the correct explanation of Statement 1.
(2) Statement 1 is false, Statement 2 is true.
(3) Statement 1 is true, Statement 2 is false.
(4) Statement 1 is true, Statement 2 is true, Statement 2 is not the correct explanation of Statement 1.

43. Two fixed frictionless inclined planes making an angle 30° and 60° with the horizontal are shown in the figure. Two blocks A and B are placed on the two planes. What is the relative vertical acceleration of A with respect to B? **[2010]**



(1) 4.9 ms^{-2} in horizontal direction
(2) 9.8 ms^{-2} in vertical direction
(3) Zero
(4) 4.9 ms^{-2} in vertical direction

44. A ball of mass 0.2 kg is thrown vertically upwards by applying a force by hand. If the hand moves 0.2 m while applying the force and the ball goes upto 2 m height further, find the magnitude of the force. (Consider $g = 10$ m/s^2).
[2006]

(1) 4 N (2) 16 N
(3) 20 N (4) 22 N

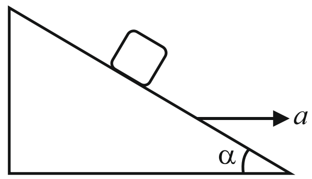
45. A player caught a cricket ball of mass 150 g moving at a rate of 20 m/s. If the catching process is completed in 0.1s, the force of the blow exerted by the ball on the hand of the player is equal to
[2006]

(1) 150 N (2) 3 N
(3) 30 N (4) 300 N

46. A particle of mass 0.3 kg subject to a force F = –*kx* with *k* = 15 N/m. What will be its initial acceleration if it is released from a point 20 cm away from the origin? **[2005]**

(1) 15 m/s^2 (2) 3 m/s^2
(3) 10 m/s^2 (4) 5 m/s^2

47. A block is kept on a frictionless inclined surface with angle of inclination 'α'. The incline is given an acceleration 'a' to keep the block stationary. Then a is equal to **[2005]**

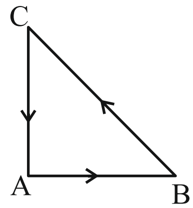


(1) g cosec α
(2) g / tan α
(3) g / tan α
(4) g

48. A rocket with a lift-off mass 3.5×10^4 kg is blasted upwards with an initial acceleration of 10 m/s^2. Then the initial thrust of the blast is **[2003]**

(1) 3.5×10^5 N
(2) 7.0×10^5 N
(3) 14.0×10^5 N
(4) 1.75×10^5 N

49. Three forces start acting simultaneously on a particle moving with velocity, $\vec{v}$. These forces are represented in magnitude and direction by the three sides of a triangle ABC. The particle will now move with velocity **[2003]**



(1) less than $\vec{v}$
(2) greater than $\vec{v}$
(3) $|\vec{v}|$ in the direction of the largest for BC
(4) $\vec{v}$, remaining unchanged

50. A solid sphere, a hollow sphere and a ring are released from top of an inclined plane (frictionless) so that they slide down the plane. Then maximum acceleration down the plane is for (no rolling) **[2002]**

(1) solid sphere
(2) hollow sphere
(3) ring
(4) all same

Motion of Connected Bodies, Pulley and Equilibrium of Forces

51. A body of mass m is suspended by two strings making angles θ_1 and θ_2 with the horizontal ceiling with tensions T_1 and T_2 simultaneously. T_1 and T_2 are related by $T_1 = \sqrt{3}T_2$, the angles θ_1 and θ_2 are **[April 4, 2025 (I)]**

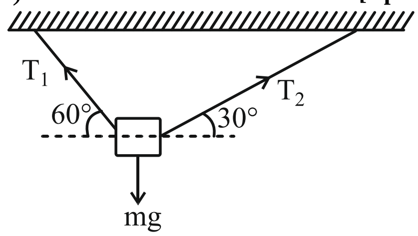
(1) $\theta_1 = 30°$ $\theta_2 = 60°$ with $T_2 = \dfrac{3mg}{4}$

(2) $\theta_1 = 60°$ $\theta_2 = 30°$ with $T_2 = \dfrac{mg}{2}$

(3) $\theta_1 = 45°$ $\theta_2 = 45°$ with $T_2 = \dfrac{3mg}{4}$

(4) $\theta_1 = 30°$ $\theta_2 = 60°$ with $T_2 = \dfrac{4mg}{5}$

52. A body of mass 1 kg is suspended with the help of two strings making angles as shown in figure. Magnitudes of tensions T_1 and T_2, respectively, are (in N): **[April 2, 2025 (II)]**



(1) $5, 5\sqrt{3}$
(2) $5\sqrt{3}, 5$
(3) $5\sqrt{3}, 5\sqrt{3}$
(4) 5, 5

53. A massless spring gets elongated by amount x_1 under a tension of 5N. Its elongation is x_2 under the tension of 7N. For the elongation of $(5x_1 - 2x_2)$, the tension in the spring will be **[Jan. 23, 2025 (II)]**

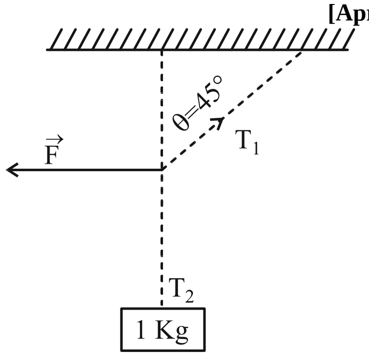
(1) 15 N
(2) 20 N
(3) 11 N
(4) 39 N

54. A light unstretchable string passing over a smooth light pulley connects two blocks of masses m_1 and m_2. If the acceleration of the system is $g/8$, then the ratio of the masses m_2/m_1 is: **[April 9, 2024 (I)]**

(1) 9 : 7
(2) 4 : 3
(3) 5 : 3
(4) 8 : 1

55. A 1 kg mass is suspended from the ceiling by a rope of length 4m. A horizontal force 'F' is applied at the mid point of the rope so that the rope makes an angle of 45° with respect to the vertical axis as shown in figure. The magnitude of F is:

[April 9, 2024 (II)]



(1) $\frac{10}{\sqrt{2}}$ N (2) 1 N

(3) $\frac{1}{10\times\sqrt{2}}$ N (4) 10 N

56. A light string passing over a smooth light pulley connects two blocks of masses m_1 and m_2 (where $m_2 > m_1$). If the acceleration of the system is $g/\sqrt{2}$, then the ratio of the masses m_1/m_2 is:

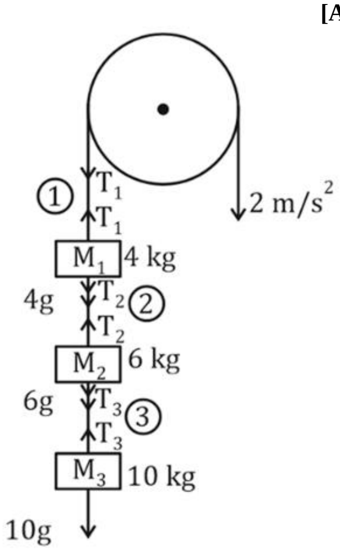
[April 6, 2024 (I)]

(1) $\frac{\sqrt{2}-1}{\sqrt{2}+1}$ (2) $\frac{1+\sqrt{5}}{\sqrt{5}-1}$

(3) $\frac{1+\sqrt{5}}{\sqrt{2}-1}$ (4) $\frac{\sqrt{3}+1}{\sqrt{2}-1}$

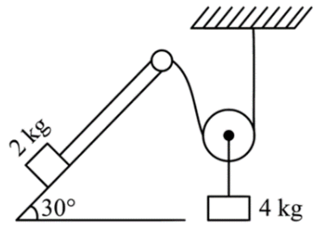
57. Three blocks M_1, M_2, M_3 having masses 4 kg, 6 kg and 10 kg respectively are hanging from a smooth pully using rope 1, 2 and 3 as shown in figure. The tension in the rope 1, T_1 when they are moving upward with acceleration of 2 ms^{-2} is__________ N (if g = 10 m/s^2).

[April 5, 2024 (I)]



58. All surfaces shown in figure are assumed to be frictionless and the pulleys and the string are light. The acceleration of the block of mass 2 kg is:

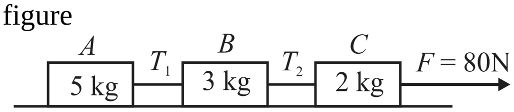
[Jan 30, 2024 (I)]



(1) g (2) $g/3$

(3) $g/2$ (4) $g/4$

59. Three blocks A, B and C are pulled on a horizontal smooth surface by a force of 80 N as shown in figure



The tensions T_1 and T_2 in the string are respectively

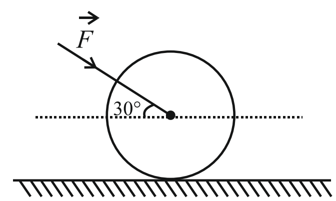
[Jan 30, 2024 (II)]

(1) 40 N, 64 N (2) 60 N, 80 N

(3) 88 N, 96 N (4) 80 N, 100 N

60. As shown in figure, a 70 kg garden roller is pushed with a force of $\vec{F} = 200$ N at an angle of 30° with horizontal. The normal reaction on the roller is _______. (Given g = 10 ms^{-2}).

[Jan 31, 2024 (I)]

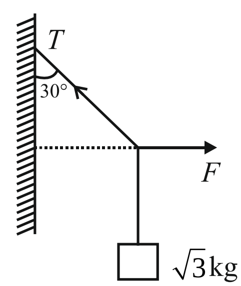


(1) $800\sqrt{2}$ N (2) 600 N

(3) 800 N (4) $200\sqrt{3}$ N

61. A block of $\sqrt{3}$ kg is attached to a string whose other end is attached to the wall. An unknown force F is applied so that the string makes an angle of 30° with the wall. The tension T is:
(Given g = 10 ms^{-2})

[Jan 30, 2023 (II)]

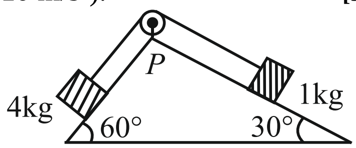


(1) 20 N (2) 25 N

(3) 10 N (4) 15 N

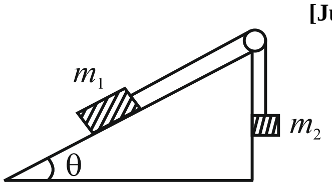
62. Given below are two statements:
Statement-I: An elevator can go up or down with uniform speed when its weight is balanced with the tension of its cable.
Statement-II: Force exerted by the floor of an elevator on the foot of a person standing on it is more than his/her weight when the elevator goes down with increasing speed.
In the light of the above statements, choose the correct answer from the options given below:
[Jan 24, 2023 (I)]
(1) Both statement I and statement II are false
(2) Statement I is true but Statement II is false
(3) Both Statement I and Statement II are true
(4) Statement I is false but Statement II is true

63. As per given figure, a weightless pulley P is attached on a double inclined frictionless surface. The tension in the string (massless) will be (if g = 10 m/s^2). **[Jan 24, 2023 (I)]**



(1) $\left(4\sqrt{3}+1\right)$N
(2) $4\left(\sqrt{3}+1\right)$N
(3) $4\left(\sqrt{3}-1\right)$N
(4) $\left(4\sqrt{3}-1\right)$N

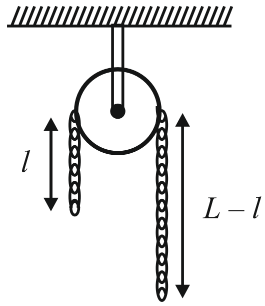
64. Two bodies of masses m_1 = 5 kg and m_2 = 3 kg are connected by a light string going over a smooth light pulley on a smooth inclined plane as shown in the figure. The system is at rest. The force exerted by the inclined plane of the body of mass m_1 will be: [Take g = 10 ms^{-2}]
[July 29, 2022 (II)]



(1) 30 N (2) 40 N
(3) 50 N (4) 60 N

65. A block 'A' takes 2s to slide down a frictionless incline of 30° and length 'l', kept inside a lift going up with uniform velocity 'v'. If the incline is changed to 45°, the time taken by the block, to slide down the incline, will be approximately:
[July 27, 2022 (II)]
(1) 2.66 s (2) 0.83 s
(3) 1.68 s (4) 0.70 s

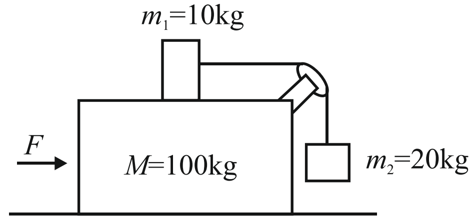
66. A uniform metal chain of mass m and length 'L' passes over a massless and frictionless pulley. It is released from rest with a part of its length 'l' is hanging on one side and rest of its length '$L - l$' is hanging on the other side of the pulley. At a certain point of time, when $l = L/x$, the acceleration of the chain is g/2. The value of x is ________.
[July 28, 2022 (II)]



(1) 6 (2) 2
(3) 1.5 (4) 4

67. A monkey of mass 50 kg climbs on a rope which can withstand the tension (T) of 350N. If monkey initially climbs down with an acceleration of 4 m/s^2 and then climbs up with an acceleration of 5m/s^2. Choose the correct option (g = 10m/s^2)
[July 26, 2022 (I)]
(1) T = 700N while climbing upward
(2) T = 350N while going downward
(3) Rope will break while climbing upward
(4) Rope will break while going downward

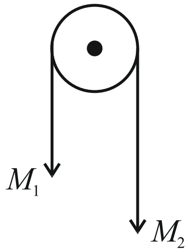
68. Three masses M = 100 kg, m_1 = 10 kg and m_2 = 20 kg are arranged in a system as shown in figure. All the surface are frictionless and strings are inextensible and weightless. The pulleys are also weightless and frictionless. A force F is applied on the system so that the mass m_2 moves upward with an acceleration of 2 ms^{-2}. The value of F is:
(Take g = 10 ms^{-2}).
[July 26, 2022 (I)]



(1) 3360 N
(2) 3380 N
(3) 3120 N
(4) 3240 N

69. Two masses M_1 and M_2 are tied together at the two ends of a light inextensible string that passes over a frictionless pulley. When the mass M_2 is twice that of M_1. The acceleration of the system is a_1. When the mass M_2 is thrice that of M_1. The acceleration of the system is a_2. The ratio a_1/a_2 will be:

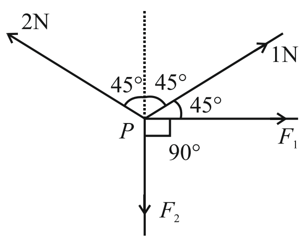
[July 26, 2022 (II)]



(1) 1/3 (2) 2/3
(3) 3/2 (4) 1/2

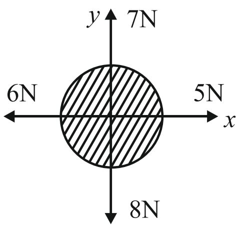
70. Four forces are acting at a point P in equilibrium as shown in figure. The ratio of force F_1 to F_2 is $1 : x$ where x =________.

[July 25, 2022 (I)]



71. For a free body diagram shown in the figure, the four forces are applied in the 'x' and 'y' directions. What additional force must be applied and at what angle with positive x-axis so that the net acceleration of body is zero?

[July 25, 2022 (II)]



(1) $\sqrt{2}$ N, 45°
(2) $\sqrt{2}$ N, 135°
(3) $\dfrac{2}{\sqrt{3}}$ N, 30°
(4) 2 N, 45°

72. A block of mass M placed inside a box descends vertically with acceleration 'a'. The block exerts a force equal to one-fourth of its weight on the floor of the box. The value of 'a' will be ________.

[June 29, 2022 (II)]

(1) $g/4$ (2) $g/2$
(3) $3g/4$ (4) g

73. A mass of 10 kg is suspended vertically by a rope of length 5 m from the roof. A force of 30 N is applied at the middle point of rope in horizontal direction. The angle made by upper half of the rope with vertical is $\theta = \tan^{-1}(x \times 10^{-1})$. The value of x is ________. (Given $g = 10\ \text{m/s}^2$).

[June 27, 2022 (II)]

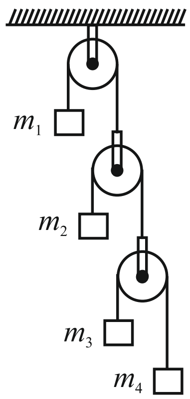
74. A person is standing in an elevator. In which situation, he experiences weight loss?

[June 26, 2022 (I)]

(1) When the elevator moves upward with constant acceleration
(2) When the elevator moves downward with constant acceleration
(3) When the elevator moves upward with uniform velocity
(4) When the elevator moves downward with uniform velocity

75. In the arrangement shown in figure a_1, a_2, a_3 and a_4 are the acceleration of masses m_1, m_2, m_3 and m_4 respectively. Which of the following relation is true for this arrangement?

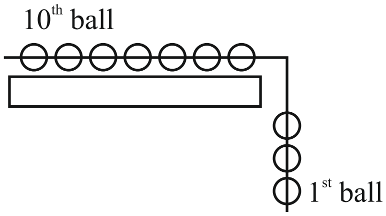
[June 26, 2022 (II)]



(1) $4a_1 + 2a_2 + a_3 + a_4 = 0$
(2) $a_1 + 4a_2 + 3a_3 + a_4 = 0$
(3) $a_1 + 4a_2 + 3a_3 + 2a_4 = 0$
(4) $2a_1 + 2a_2 + 3a_3 + a_4 = 0$

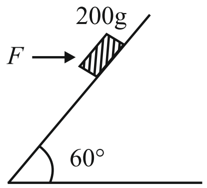
76. A system of 10 balls each of mass 2 kg are connected via massless and un-stretchable string. The system is allowed to slip over the edge of a smooth table as shown in figure. Tension on the string between the 7th and 8th ball is ________ N when 6th ball just leaves the table.

[June 26, 2022 (II)]

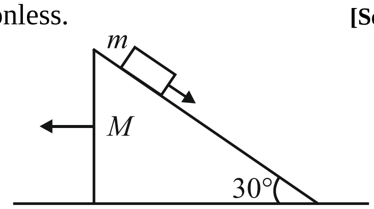


77. A block of mass 200 g is kept stationary on a smooth inclined plane by applying a minimum horizontal force $F = \sqrt{x}$ N as shown in figure. The value of x = _______.

[June 25, 2022 (II)]



78. A block of mass m slides on the wooden wedge, which in turn slides backward on the horizontal surface. The acceleration of the block with respect to the wedge is: Given $m = 8$ kg, $M = 16$ kg. Assume all the surfaces shown in the figure to be frictionless. **[Sep. 1, 2021 (II)]**



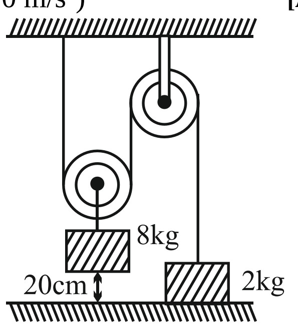
(1) $\frac{4}{3}$ g (2) $\frac{6}{5}$ g

(3) $\frac{3}{5}$ g (4) $\frac{2}{3}$ g

79. A car is moving on a plane inclined at 30º to the horizontal with an acceleration of 10 ms^{-2} parallel to the plane upward. A bob is suspended by a string from the roof of the car. The angle in degrees which the string makes with the vertical is______.
(Take g = 10 ms^{-2})

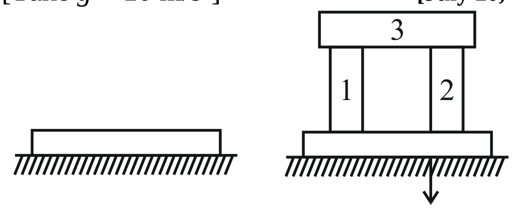
[Aug. 31, 2021 (I)]

80. The boxes of masses 2 kg and 8 kg are connected by a massless string passing over smooth pulleys. Calculate the time taken by box of mass 8 kg to strike the ground starting from rest.
(use g = 10 m/s^2) **[Aug. 27, 2021 (II)]**



(1) 0.34 s (2) 0.2 s
(3) 0.25 s (4) 0.4 s

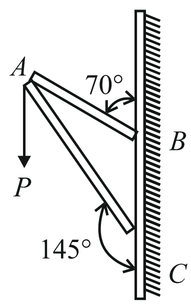
81. A steel block of 10 kg rests on a horizontal floor as shown. When three iron cylinders are placed on it as shown, the block and cylinders go down with an acceleration 0.2 m/s^2. The normal reaction R' by the floor if mass of the iron cylinders are equal and of 20 kg each, is _______N.
[Take g = 10 m/s^2] **[July 20, 2021 (I)]**



(1) 716 (2) 686
(3) 714 (4) 684

82. Consider a frame that is made up of two thin massless rods AB and AC as shown in the figure. A vertical force $\vec{P}$ of magnitude 100 N is applied at point A of the frame. Suppose the force is $\vec{P}$ resolved parallel to the arms AB and AC of the frame. The magnitude of the resolved component along the arm AC is xN. The value of x, to the nearest integer, is ________.
[Given: sin(35°) = 0.573, cos(35°) = 0.819, sin(110°) = 0.939, cos(110°) = –0.342]

[March 16, 2021 (I)]



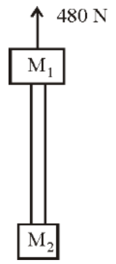
83. A person standing on a spring balance inside a stationary lift measures 60 kg. The weight of that person if the lift descends with uniform downward acceleration of 1.8 m/s^2 will be _______N.
[g =10 m/s^2] **[Feb. 26, 2021 (I)]**

84. A mass of 10 kg is suspended by a rope of length 4 m, from the ceiling. A force F is applied horizontally at the mid-point of the rope such that the top half of the rope makes an angle of 45° with the vertical. Then F equals: (Take g = 10 ms^{-2} and the rope to be massless)

[9 Jan. 2019 II, 7 Jan. 2020 (II)]

(1) 100 N
(2) 90 N
(3) 70 N
(4) 75 N

85. Two blocks of mass $M_1 = 20$ kg and $M_2 = 12$ kg are connected by a metal rod of mass 8 kg. The system is pulled vertically up by applying a force of 480 N as shown. The tension at the mid-point of the rod is: **[April 22, 2013]**



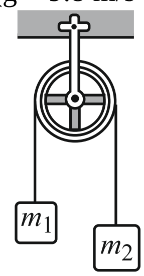
(1) 144 N (2) 96 N
(3) 240 N (4) 192 N

86. A block of mass m is connected to another block of mass M by a spring (massless) of spring constant k. The blocks are kept on a smooth horizontal plane. Initially the blocks. are at rest and the spring is unstretched. Then a constant force F starts acting on the block of mass M to pull it. Find the force on the block of mass m. **[2007]**

(1) $\frac{MF}{(m+M)}$ (2) $\frac{mF}{M}$

(3) $\frac{(M+m)F}{m}$ (4) $\frac{mF}{(m+M)}$

87. Two masses $m_1 = 5$ kg and $m_2 = 4.8$ kg tied to a string are hanging over a light frictionless pulley. What is the acceleration of the masses when left free to move ? ($g = 9.8$ m/s^2) **[2004]**



(1) 5 m/s^2 (2) 9.8 m/s^2
(3) 0.2 m/s^2 (4) 4.8 m/s^2

88. A spring balance is attached to the ceiling of a lift. A man hangs his bag on the spring and the spring reads 49 N, when the lift is stationary. If the lift moves downward with an acceleration of 5 m/s^2, the reading of the spring balance will be **[2003]**

(1) 24 N
(2) 74 N
(3) 15 N
(4) 49 N

89. A block of mass M is pulled along a horizontal frictionless surface by a rope of mass m. If a force P is applied at the free end of the rope, the force exerted by the rope on the block is: **[2003]**

(1) $\frac{Pm}{M+m}$

(2) $\frac{Pm}{M-m}$

(3) P

(4) $\frac{PM}{M+m}$

90. A light spring balance hangs from the hook of the other light spring balance and a block of mass M kg hangs from the former one. Then the true statement about the scale reading is **[2003]**

(1) both the scales read M kg each
(2) the scale of the lower one reads M kg and of the upper one zero
(3) the reading of the two scales can be anything but the sum of the reading will be Mkg
(4) both the scales read M/2 kg each

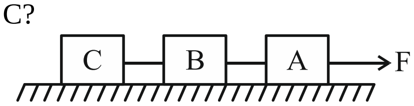
91. A lift is moving down with acceleration a. A man in the lift drops a ball inside the lift. The acceleration of the ball as observed by the man in the lift and a man standing stationary on the ground are respectively **[2002]**

(1) g, g (2) $g - a, g - a$
(3) $g - a, g$ (4) a, g

92. When forces F_1, F_2, F_3 are acting on a particle of mass m such that F_2 and F_3 are mutually perpendicular, then the 2 particle remains stationary. If the force F_1 is now removed then the acceleration of the particle is **[2002]**

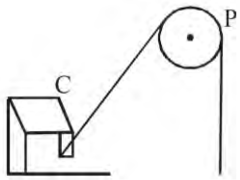
(1) F_1/m
(2) F_2F_3/mF_1
(3) $(F_2–F_3)/m$
(4) F_2/m

93. Three identical blocks of masses $m = 2$kg are drawn by a force F = 10 2 N with an acceleration of 0.6 ms^{-2} on a frictionless surface, then what is the tension (in N) in the string between the blocks B and C? **[2002]**



(1) 9.2 (2) 3.4
(3) 4 (4) 9.8

94. One end of a massless rope, which passes over a massless and frictionless pulley P is tied to a hook C while the other end is free. Maximum tension that the rope can bear is 360 N. With what value of maximum safe acceleration (in ms^{-2}) can a man of 60 kg climb on the rope? **[2002]**



(1) 16 (2) 6
(3) 4 (4) 8

FRICTION

95. A cubic block of mass *m* is sliding down on an inclined plane at 60° with an acceleration *g*/2, of, the value of coefficient of kinetic friction is **[April 7, 2025 (I)]**

(1) $\sqrt{3}-1$ (2) $\sqrt{3}/2$
(3) $\sqrt{2}/3$ (4) $1-\frac{\sqrt{3}}{2}$

96. A block of mass 25 kg is pulled along a horizontal surface by a force at an angle 45° with the horizontal. The friction coefficient between the block and the surface is 0.25. The displacement of 5 m of the block is: **[April 4, 2025 (II)]**

(1) 970 J (2) 735 J
(3) 245 J (4) 490 J

97. A given object takes n times the time to slide down 45° rough inclined plane as it takes the time to slide down an identical perfectly smooth 45° inclined plane. The coefficient of kinetic friction between the object and the surface of inclined plane is: **[April 8, 2024 (II)]**

(1) $1-\frac{1}{n^2}$ (2) $1-n^2$
(3) $\sqrt{1-\frac{1}{n^2}}$ (4) $\sqrt{1-n^2}$

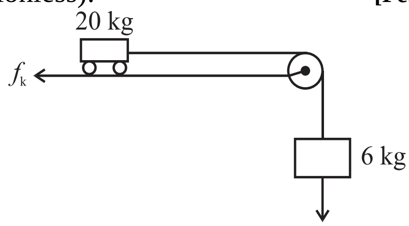
98. A heavy box of mass 50 kg is moving on a horizontal surface. If co-efficient of kinetic friction between the box and horizontal surface is 0.3 then force of kinetic friction is: **[April 5, 2024 (II)]**

(1) 14.7 N
(2) 147 N
(3) 1.47 N
(4) 1470 N

99. A 2 kg brick begins to slide over a surface which is inclined at an angle of 45° with respect to horizontal axis. The co-efficient of static friction between their surfaces is: **[April 4, 2024 (II)]**

(1) 1 (2) $1/\sqrt{3}$
(3) 0.5 (4) 1.7

100. Consider a block and trolley system as shown in figure. If the coefficient of kinetic friction between the trolley and the surface is 0.04, the acceleration of the system in ms^{-2} is:
(Consider that the string is massless and unstretchable and the pulley is also massless and frictionless): **[Feb. 1, 2024 (I)]**

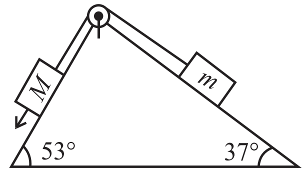


(1) 3 (2) 4
(3) 2 (4) 1.2

101. A coin is placed on a disc. The coefficient of friction between the coin and the disc is μ. If the distance of the coin from the center of the disc is *r*, the maximum angular velocity which can be given to the disc, so that the coin does not slip away, is: **[Jan. 31, 2024 (I)]**

(1) $\frac{\mu}{\sqrt{rg}}$ (2) $\sqrt{\frac{\mu g}{r}}$
(3) $\frac{\mu g}{r}$ (4) $\sqrt{\frac{r}{\mu g}}$

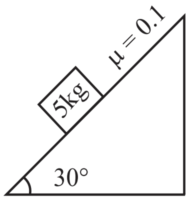
102. In the given arrangement of a doubly inclined plane two blocks of masses M and *m* are placed. The blocks are connected by a light string passing over an ideal pulley as shown. The coefficient of friction between the surface of the plane and the blocks is 0.25. The value of *m*, for which M = 10 kg will move down with an acceleration of 2 m/s^2, is:
(take g = 10 m/s^2 and tan37° = 3/4) **[Jan. 31, 2024 (I)]**



(1) 6.5 kg (2) 4.5 kg
(3) 2.25 kg (4) 9 kg

103. A block of mass 5 kg is placed on a rough inclined surface as shown in the figure. If $\vec{F}_1$ is the force required to just move the block up the inclined plane and $\vec{F}_2$ is the force required to just prevent the block from sliding down, then the value of $|\vec{F}_1|-|\vec{F}_2|$ is: [Use g = 10 m/s^2].

[Jan. 31, 2024 (II)]



(1) $25\sqrt{3}$ N (2) $5\sqrt{3}$ N

(3) $\frac{5\sqrt{3}}{2}$ N (4) 10 N

104. A block of mass m is placed on a surface having vertical cross section given by $y = x^2/4$. If coefficient of friction is 0.5, the maximum height above the ground at which block can be placed without slipping is:

[Jan. 30, 2024 (II)]

(1) 1/4 m (2) 1/2 m
(3) 1/6 m (4) 1/3 m

105. Given below are two statements:
Statement (I): The limiting force of static friction depends on the area of contact and independent of materials.
Statement (II): The limiting force of kinetic friction is independent of the area of contact and depends on materials.
In the light of the above statements, choose the most appropriate answer from the options given below:

[Jan. 27, 2024 (II)]

(1) Statement I is correct but Statement II is incorrect
(b) Statement I is incorrect but Statement II is correct
(c) Both Statement I and Statement II are incorrect
(d) Both Statement I and Statement II are correct

106. A coin placed on a rotating table just slips when it is placed at a distance of 1 cm from the centre. If the angular velocity of the table is halved, it will just slip when placed at a distance of _______ from the centre: **[April 11, 2023 (I)]**

(1) 2 cm (2) 1 cm
(3) 8 cm (4) 4 cm

107. A bullet of mass 0.1 kg moving horizontally with speed 400 ms^{-1} hits a wooden block of mass 3.9 kg kept on a horizontal rough surface. The bullet gets embedded into the block and moves 20 m before coming to rest. The coefficient of friction between the block and the surface is ________.
(Given g = 10 ms^2)

[April 8, 2023 (II)]

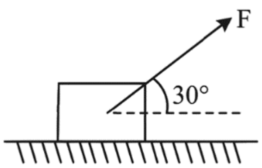
(1) 0.50 (2) 0.90
(3) 0.65 (4) 0.25

108. A block of mass 5 kg is placed at rest on a table of rough surface. Now, if a force of 30 N is applied in the direction parallel to surface of the table, the block slides through a distance of 50 m in an interval of time 10 s. Coefficient of kinetic friction is: (given, g = 10 ms^{-2})

[Feb. 1, 2023 (I)]

(1) 0.50 (2) 0.60
(3) 0.75 (4) 0.25

109. As shown in the figure a block of mass 10 kg lying on a horizontal surface is pulled by a force F acting at an angle 30°, with horizontal. For μ_s = 0.25, the block will just start to move for the value of F: [Given g = 10 ms^{-2}] **[Feb. 1, 2023 (I)]**



(1) 20 N (2) 33.3 N
(3) 25.2 N (4) 35.7 N

110. A body of mass 10 kg is moving with an initial speed of 20 m/s. The body stops after 5 s due to friction between body and the floor. The value of the coefficient of friction is:
(Take acceleration due to gravity g = 10 ms^{-2})

[Jan.29, 2023 (I)]

(1) 0.2
(2) 0.3
(3) 0.5
(4) 0.4

111. A block of mass m slides down the plane inclined at angle 30° with an acceleration g/4. The value of coefficient of kinetic friction will be:

[Jan. 29, 2023 (I)]

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

(3) $\frac{\sqrt{3}}{2}$ (4) $\frac{2\sqrt{3}-1}{2}$

112. The time taken by an object to slide down 45° rough inclined plane is n times as it takes to slide down a perfectly smooth 45° incline plane. The coefficient of kinetic friction between the object and the incline plane is ________.

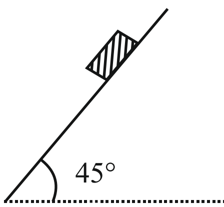
[Jan. 29, 2023 (II)]

(1) $\sqrt{\frac{1}{1-n^2}}$ (2) $\sqrt{1-\frac{1}{n^2}}$

(3) $1+\frac{1}{n^2}$ (4) $1-\frac{1}{n^2}$

113. Consider a block kept on an inclined plane (inclined at 45°) as shown in the figure. If the force required to just push it up the incline is 2 times the force required to just prevent it from sliding down, the coefficient of friction between the block and inclined plane (μ) is equal to:

[Jan. 25, 2023 (II)]



(1) 0.33 (2) 0.60

(3) 0.25 (4) 0.50

114. A bag is gently dropped on a conveyor belt moving at a speed of 2 m/s. The coefficient of friction between the conveyor belt and bag is 0.4 Initially, the bag slips on the belt before is stops due to friction. The distance travelled by the bag on the belt during slipping motion is: [Take g = 10 m/s^{-2}]

[July 27, 2022 (I)]

(1) 2 m (2) 0.5 m

(3) 3.2 m (4) 0.8 m

115. A block of mass M slides down on a rough inclined plane with constant velocity. The angle made by the incline plane with horizontal is θ. The magnitude of the contact force will be: **[July 27, 2022 (II)]**

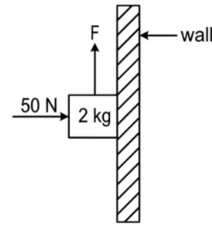
(1) Mg

(2) $Mg\cos\theta$

(3) $\sqrt{Mg\sin\theta + Mg\cos\theta}$

(4) $Mg\sin\theta\sqrt{1+\mu}$

116. A 2 kg block is pushed against a vertical wall by applying a horizontal force of 50 N. The coefficient of static friction between the block and the wall is 0.5. A force F is also applied on the block vertically upward (as shown in figure). The maximum value of F applied, so that the block does not move upward, will be: **[June 30, 2022 (I)]**

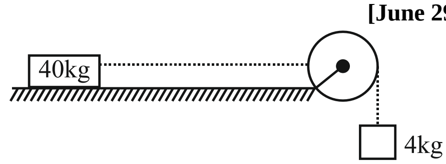


(1) 10 N (2) 20 N

(3) 25 N (4) 45 N

117. A block of mass 40 kg slides over a surface, when a mass of 4 kg is suspended through an inextensible massless string passing over frictionless pulley as shown below. The coefficient of kinetic friction between the surface and block is 0.02. The acceleration of block is ________.
(Given g = 10 ms^{-2})

[June 29, 2022 (II)]

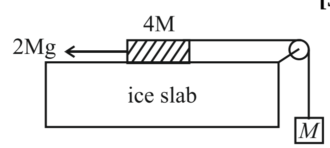


(1) 1 ms^{-2} (2) 1/5 ms^{-2}

(3) 4/5 ms^{-2} (4) 8/11 ms^{-2}

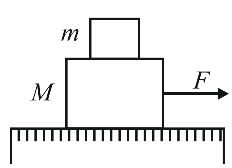
118. A hanging mass M is connected to a four times bigger mass by using a string-pulley arrangement. as shown in the figure. The bigger mass is placed on a horizontal ice-slab and being pulled by 2Mg force. In this situation tension in the string is x/5 mg for x = _________. Neglect mass of the string and friction of the block (bigger mass) with ice slab.
(Given g = acceleration due to gravity)

[June 28, 2022 (I)]



119. A system of two blocks of masses m = 2 kg and M = 8 kg is placed on a smooth table as shown in figure. The coefficient of static friction between two blocks is 0.5. The maximum horizontal force F that can be applied to the block of mass M so that the blocks move together will be:

[June 27, 2022 (I)]



(1) 9.8 N (2) 39.2 N

(3) 49 N (4) 78.4 N

120. A disc with a flat small bottom beaker placed on it at a distance R from its centre is revolving about an axis passing through the centre and perpendicular to its plane with an angular velocity ω. The coefficient of static of the disc is μ. The beaker will revolve with disc if:

[June 25, 2022 (II)]

(1) $R \le \frac{\mu g}{2\omega^2}$ (2) $R \le \frac{\mu g}{\omega^2}$

(3) $R \ge \frac{\mu g}{2\omega^2}$ (4) $R \ge \frac{\mu g}{\omega^2}$

121. A block of mass 10 kg starts sliding on a surface with an initial velocity of 9.8 ms^{-1}. The coefficient of friction between the surface and block is 0.5. The distance covered by the block before coming to rest in [use g = 9.8 ms^{-2}]

[June 24, 2022 (I)]

(1) 4.9 m (2) 9.8 m

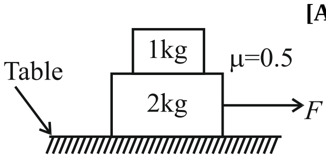
(3) 12.5 m (4) 19.6 m

122. When a body slides down from rest along a smooth inclined plane making an angle of 30° with the horizontal, it takes time T. When the same body slides down from the rest along a rough inclined plane making the same angle and through the same distance, it takes time αT, where α is a constant greater than 1. The coefficient of friction between the body and the rough plane is $\frac{1}{\sqrt{x}}\left(\frac{\alpha^2-1}{\alpha^2}\right)$ where x =________

[Sep. 1, 2021 (II)]

123. The coefficient of static friction between two blocks is 0.5 and the table is smooth. The maximum horizontal force that can be applied to move the blocks together is ______ N. (Take: g = 10 ms^{-2})

[Aug. 26, 2021 (II)]

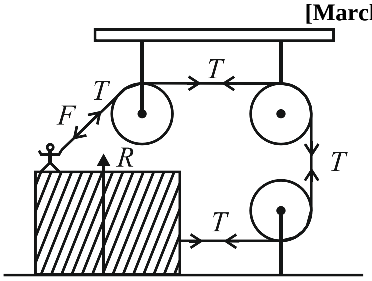


124. A body of mass 'm' is launched up on a rough inclined plane making an angle of 30° with the horizontal. The coefficient of friction between the body and plane is $\frac{\sqrt{x}}{5}$ if the time of ascent is half of the time of descent. The value of x is _______

[July 20, 2021 (II)]

125. A boy of mass 4 kg is standing on a piece of wood having mass 5kg. If the coefficient of friction between the wood and the floor is 0.5, the maximum force that the boy can exert on the rope so that the piece of wood does not move from its place is ________N.
(Round off to the Nearest Integer)
[Take g = 10 ms^{-2}]

[March 17, 2021 (II)]



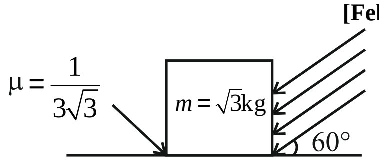
126. A body of mass 1 kg rests on a horizontal floor with which it has a coefficient of static friction $\frac{1}{\sqrt{3}}$. It is desired to make the body move by applying the minimum possible force F N. The value of F will be.
(Round off to the Nearest Integer)
[Take g = 10 ms^{-2}].

[March 17, 2021 (II)]

127. As shown in the figure, a block of mass $\sqrt{3}$ kg is kept on a horizontal rough surface of coefficient of friction $\frac{1}{x}\left(\frac{\alpha^2-1}{\alpha^2}\right)$. The critical force to be applied on the vertical surface as shown at an angle 60° with horizontal such that it does not move, will be $3x$. The value of x will be:

[g = 10 m/s²; $\sin 60° = \frac{\sqrt{3}}{2}$; $\cos 60° = \frac{1}{2}$]

[Feb. 26, 2021 (I)]



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

[Feb. 24, 2021 (I), 2003 S]

129. The coefficient of static friction between a wooden block of mass 0.5 kg and a vertical rough wall is 0.2. The magnitude of horizontal force that should be applied on the block to keep it adhere to the wall will be ___________ N. [$g = 10\ ms^{-2}$]

[Feb. 24, 2021 (I)]

130. An insect is at the bottom of a hemispherical ditch of radius 1 m. It crawls up the ditch but starts slipping after it is at height h from the bottom. If the coefficient of friction between the ground and the insect is 0.75, then h is ($g = 10\ ms^{-2}$)

[Sep. 06, 2020 (I)]

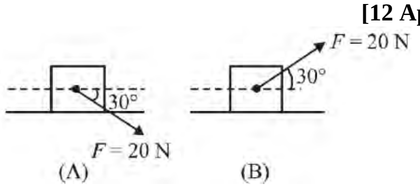
(1) 0.20 m (2) 0.45 m
(3) 0.60 m (4) 0.80 m

131. A block starts moving up an inclined plane of inclination 30° with an initial velocity of v_0. It comes back to its initial position with velocity $v_0/2$. The value of the coefficient of kinetic friction between the block and the inclined plane is close to $I/1000$. The nearest integer to I is _________.

[Sep. 03, 2020 (II)]

132. A block of mass 5 kg is (i) pushed in case (A) and (ii) pulled in case (B), by a force $F = 20$ N, making an angle of 30° with the horizontal, as shown in the figures. The coefficient of friction between the block and floor is $\mu = 0.2$. The difference between the accelerations of the block, in case (B) and case (A) will be: ($g = 10\ ms^{-2}$)

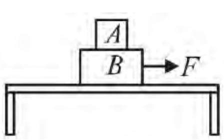
[12 April 2019 II]



(1) $0.4\ ms^{-2}$ (2) $3.2\ ms^{-2}$
(3) $0.8\ ms^{-2}$ (4) $0\ ms^{-2}$

133. Two blocks A and B masses m_A = 1 kg and m_B = 3 kg are kept on the table as shown in figure. The coefficient of friction between A and B is 0.2 and between B and the surface of the table is also 0.2. The maximum force F that can be applied on B horizontally, so that the block A does not slide over the block B is: [Take g = 10 m/s^2]

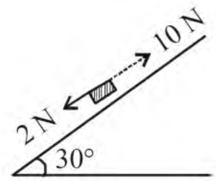
[10 April 2019 II]



(1) 8 N (2) 16 N
(3) 40 N (4) 12 N

134. A block kept on a rough inclined plane, as shown in the figure, remains at rest upto a maximum force 2 N down the inclined plane. The maximum external force up the inclined plane that does not move the block is 10 N. The coefficient of static friction between the block and the plane is:
[Take g = 10 m/s^2]

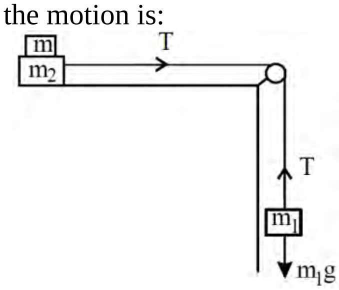
[12 Jan. 2019 II]



(1) $\sqrt{3}/2$ (2) $\sqrt{3}/4$
(3) 1/2 (4) 2/3

135. Two masses m_1 = 5 kg and m_2 = 10 kg connected by an inextensible string over a frictionless pulley, are moving as shown in the figure. The coefficient of friction of horizontal surface is 0.15. The minimum weight m that should be put on top of m_2 to stop the motion is:

[2018]



(1) 18.3 kg (2) 23.3 kg
(3) 43.3 kg (4) 10.3 kg

136. A body of mass 2 kg slides down with an acceleration of 3 m/s^2 on a rough inclined plane having a slope of 30°. The external force required to take the same body up the plane with the same acceleration will be: (g = 10 m/s^2)

[Online April 15, 2018]

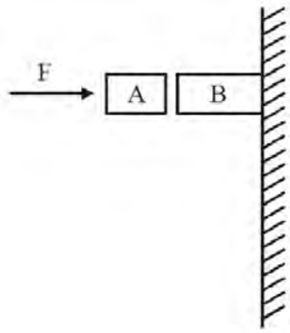
(1) 4 N (2) 14 N
(3) 6 N (4) 20 N

137. A rocket is fired vertically from the earth with an acceleration of 2g, where g is the gravitational acceleration. On an inclined plane inside the rocket, making an angle 0 with the horizontal, a point object of mass m is kept. The minimum coefficient of friction μ_{min} between the mass and the inclined surface such that the mass does not move is:

[Online April 9, 2016]

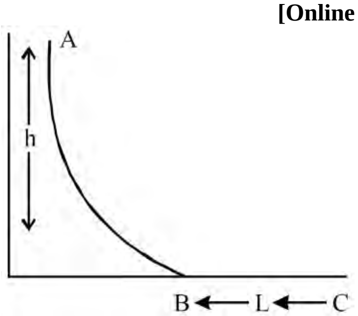
(1) tan2θ
(2) tanθ
(3) 3 tanθ
(4) 2 tanθ

138. Given in the figure are two blocks A and B of weight 20 N and 100 N, respectively. These are being pressed against a wall by a force F as shown. If the coefficient of friction between the blocks is 0.1 and between block B and the wall is 0.15, the frictional force applied by the wall on block B is: **[2015]**



(1) 120 N (2) 150 N
(3) 100 N (4) 80 N

139. A small ball of mass *m* starts at a point A with speed v_0 and moves along a frictionless track AB as shown. The track BC has coefficient of friction μ. The ball comes to stop at C after travelling a distance L which is: **[Online April 11, 2014]**

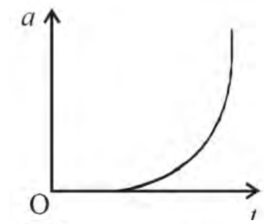


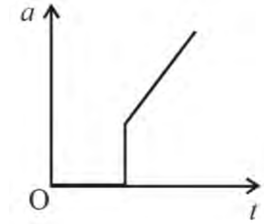
(1) $\frac{2h}{\mu}+\frac{v_0^2}{2\mu g}$ (2) $\frac{h}{\mu}+\frac{v_0^2}{2\mu g}$
(3) $\frac{h}{2\mu}+\frac{v_0^2}{\mu g}$ (4) $\frac{h}{2\mu}+\frac{v_0^2}{2\mu g}$

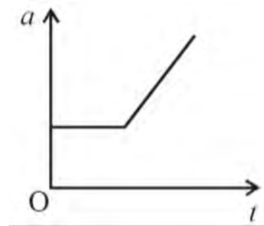
140. A block A of mass 4 kg is placed on another block B of mass 5 kg, and the block B rests on a smooth horizontal table. If the minimum force that can be applied on A so that both the blocks move together is 12 N, the maximum force that can be applied to B for the blocks to move together will be: **[Online April 9, 2014]**

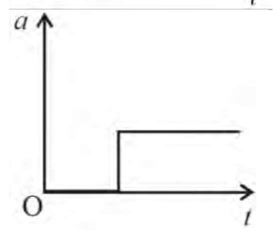
(1) 30 N (2) 25 N
(3) 27 N (4) 48 N

141. A block is placed on a rough horizontal plane. A time dependent horizontal force F = *kt* acts on the block, where *k* is a positive constant. The acceleration - time graph of the block is: **[Online April 25, 2013]**

(1)


(2)


(3)


(4)


142. A body starts from rest on a long inclined plane of slope 45°. The coefficient of friction between the body and the plane varies as μ = 0.3 *x*, where *x* is distance travelled down the plane. The body will have maximum speed (for g = 10 m/s^2) when *x* = **[Online April 22, 2013]**

(1) 9.8 m (2) 27 m
(3) 12 m (4) 3.33 m

143. The minimum force required to start pushing a body up rough (frictional coefficient μ) inclined plane is F_1 while the minimum force needed to prevent it from sliding down is F_2. If the inclined plane makes an angle θ from the horizontal such that tan θ = 2μ then the ratio of F_1/F_2 is **[2011]**

(1) 1 (2) 2
(3) 3 (4) 4

144. The upper half of an inclined plane with inclination ϕ is perfectly smooth while the lower half is rough. A body starting from rest at the top will again come to rest at the bottom if the coefficient of friction for the lower half is given by **[2005]**

(1) 2 cos ϕ (2) 2 sin ϕ
(3) tan ϕ (4) 2 tan θ

145. Consider a car moving on a straight road with a speed of 100 m/s. The distance at which car can be stopped is [$\mu_k = 0.5$] **[2005]**
(1) 1000 m (2) 800 m
(3) 400 m (4) 100 m

146. A block rests on a rough inclined plane making an angle of 30° with the horizontal. The coefficient of static friction between the block and the plane is 0.8. If the frictional force on the block is 10 N, the mass of the block (in kg) is
(take $g = 10$ m/s^2) **[2004]**
(1) 1.6 (2) 4.0
(3) 2.0 (4) 2.5

147. A marble block of mass 2 kg lying on ice when given a velocity of 6 m/s is stopped by friction in 10 s. Then the coefficient of friction is **[2003]**
(1) 0.02 (2) 0.03
(3) 0.04 (4) 0.06

CIRCULAR MOTION, BANKING OF ROAD

148. A car of mass 'm' moves on a banked road having radius 'r' and banking angle θ. To avoid slipping from banked road, the maximum permissible speed of the car is v_0. The coefficient of friction μ between the wheels of the car and the banked road is **[Jan. 24, 2025 (I)]**

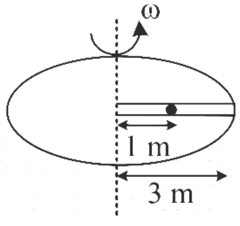
(1) $\mu = \dfrac{v_0^2 + rg\tan\theta}{rg - v_0^2\tan\theta}$

(2) $\mu = \dfrac{v_0^2 + rg\tan\theta}{rg + v_0^2\tan\theta}$

(3) $\mu = \dfrac{v_0^2 - rg\tan\theta}{rg + v_0^2\tan\theta}$

(4) $\mu = \dfrac{v_0^2 - rg\tan\theta}{rg - v_0^2\tan\theta}$

149. A circular table is rotating with an angular velocity of ω rad/s about its axis (see figure). There is a smooth groove along a radial direction on the table. A steel ball is gently placed at a distance of 1 m on the groove. All the surface are smooth. If the radius of the table is 3 m, the radial velocity of the ball w.r.t. the table at the time ball leaves the table is $x\sqrt{2}\omega$ m/s, where the value of x is ________ **[April 8, 2024 (II)]**



150. A car of 800 kg is taking turn on a banked road of radius 300 m and angle of banking 30°. If coefficient of static friction is 0.2 then the maximum speed with which car can negotiate the turn safely: (g = 10 m/s^2, $\sqrt{3} = 1.73$) **[April 6, 2024 (II)]**
(1) 70.4 m/s
(2) 51.4 m/s
(3) 264 m/s
(4) 102.8 m/s

151. A man carrying a monkey on his shoulder does cycling smoothly on a circular track of radius 9m and completes 120 revolutions in 3 minutes. The magnitude of centripetal acceleration of monkey is (in m/s^2): **[April 5, 2024 (II)]**
(1) zero
(2) $16\pi^2$ ms^{-2}
(3) $4\pi^2$ ms^{-2}
(4) $57600\pi^2$ ms^{-2}

152. A ball of mass 0.5 kg is attached to a string of length 50 cm. The ball is rotated on a horizontal circular path about its vertical axis. The maximum tension that the string can bear is 400 N. The maximum possible value of angular velocity of the ball in rad/s is: **[Feb. 1, 2024 (I)]**
(1) 1600 (2) 40
(3) 1000 (4) 20

153. If the radius of curvature of the path of two particles of same mass are in the ratio 3 : 4, then in order to have constant centripetal force, their velocities will be in the ratio of: **[Jan. 29, 2024 (I)]**
(1) $1:\sqrt{3}$ (2) $\sqrt{3}:1$
(3) $\sqrt{3}:2$ (4) $2:\sqrt{3}$

154. A train is moving with a speed of 12 m/s on rails which are 1.5 m apart. To negotiate a curve radius 400 m, the height by which the outer rail should be raised with respect to the inner rail is
(Given, $g = 10$ m/s^2): **[Jan. 27, 2024 (I)]**
(1) 6.0 cm (2) 5.4 cm
(3) 4.8 cm (4) 4.2 cm

155. A stone of mass 900 g is tied to a string and moved in a vertical circle of radius 1 m making 10 rpm. The tension in the string, when the stone is at the lowest point is:
(if $\pi^2 = 9.8$ and $g = 9.8$ m/s^2) **[Jan. 29, 2024 (II)]**
(1) 17.8 N (2) 8.82 N
(3) 97 N (4) 9.8 N

156. A vehicle of mass 200 kg is moving along a levelled curved road of radius 70 m with angular velocity of 0.2 rad/s. The centripetal force acting on the vehicle is: **[April 13, 2023 (I)]**

(1) 560 N (2) 2800 N
(3) 14 N (4) 2240 N

157. A child of mass 5 kg is going round a merry-go-round that makes 1 rotation in 3.14 s. The radius of the merry-go-round is 2 m. The centrifugal force on the child will be **[April 6, 2023 (II)]**

(1) 80 N (2) 50 N
(3) 100 N (4) 40 N

158. A car is moving on a horizontal curved road with radius 50 m. The approximate maximum speed of car will be, if friction between tyres and road is 0.34. [take $g = 10$ ms^{-2}] **[Jan. 29, 2023 (I)]**

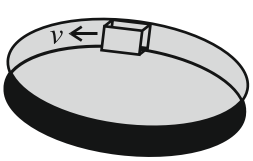
(1) 3.4 ms^{-1} (2) 22.4 ms^{-1}
(3) 13 ms^{-1} (4) 17 ms^{-1}

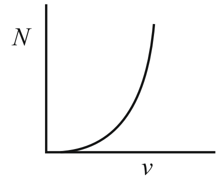
159. A car is moving on a circular path of radius 600 m such that the magnitudes of the tangential acceleration and centripetal acceleration are equal. The time taken by the car to complete first quarter of revolution, if it is moving with an initial speed of 54 km/hr is $t(1 - e^{-\pi/2})$s. The value of t is ______. **[Jan. 29, 2023 (II)]**

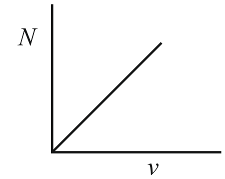
160. A car is moving with a constant speed of 20 m/s in a circular horizontal track of radius 40 m. A bob is suspended from the roof of the car by a massless string. The angle made by the string with the vertical will be: (Take $g = 10$ m/s^2) **[Jan. 25, 2023 (I)]**

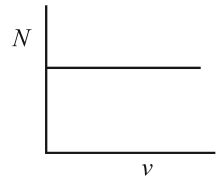
(1) $\pi/6$ (2) $\pi/2$
(3) $\pi/4$ (4) $\pi/3$

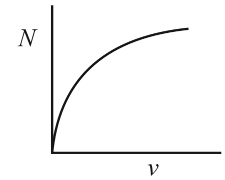
161. A smooth circular groove has a smooth vertical wall as shown in figure. A block of mass m moves against the wall with a speed v. Which of the following curve represents the correct relation between the normal reaction on the block by the wall (N) and speed of the block (v)? **[July 29, 2022 (I)]**



(1) 

(2) 

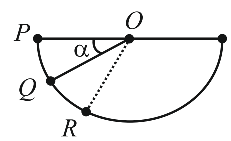
(3) 

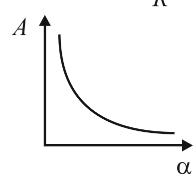
(4) 

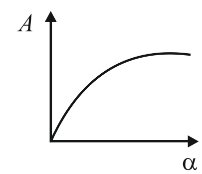
162. A stone tide to a spring of length L is whirled in a vertical circle with the other end of the spring at the centre. At a certain instant of time, the stone is at its lowest position and has a speed u. The magnitude of change in its velocity, as it reaches a position where the string is horizontal, is $\sqrt{x(u^2 - gL)}$. The value of x is: **[June 27, 2022 (II)]**

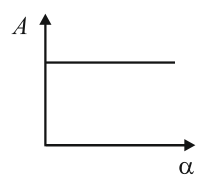
(1) 3 (2) 2
(3) 1 (4) 5

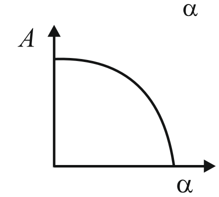
163. A ball is released from rest from point P of a smooth semi-spherical vessel as shown in figure. The ratio of the centripetal force and normal reaction on the ball at point Q is A while angular position of point Q is α with respect to point P. Which of the following graphs represent the correct relation between A and α when ball goes from Q to R? **[June 26, 2022 (I)]**



(1) 

(2) 

(3) 

(4) 

164. A curved in a level road has a radius 75 m. The maximum speed of a car turning this curved road can be 30 m/s without skidding. If radius of curved road is changed to 48 m and the coefficient of friction between the tyres and the road remains same, then maximum allowed speed would be ______m/s. **[June 25, 2022 (II)]**

165. A boy ties a stone of mass 100 g to the end of a 2 m long string and whirls it around in a horizontal plane. The string can withstand the maximum tension of 80 N. If the maximum speed with which the stone can revolve is $\frac{K}{\pi}$ rev./min. The value of K is (Assume the string is massless and unstretchable)

[June 24, 2022 (I)]

(1) 400 (2) 300
(3) 600 (4) 800

166. A stone of mass m, tied to a string is being whirled in a vertical circle with a uniform speed. The tension in the string is

[June 24, 2022 (II)]

(1) the same throughout the motion.
(2) minimum at the highest position of the circular path.
(3) minimum at the lowest position of the circular path.
(4) minimum when the rope is in the horizontal position.

167. A particle of mass *m* is suspended from a ceiling through a string of length L. The particle moves in a horizontal circle of radius r such that $r = \frac{L}{\sqrt{2}}$. The speed of particle will be:

[Aug. 26, 2021 (II)]

(1) $\sqrt{rg}$ (2) $\sqrt{2rg}$
(3) $2\sqrt{rg}$ (4) $\sqrt{rg/2}$

168. A block of 200 g mass moves with a uniform speed in a horizontal circular groove, with vertical side walls of radius 20 cm. If the block takes 40 s to complete one round, the normal force by the side walls of the groove is

[March 16, 2021 (I)]

(1) 9.859×10^{-2} N
(2) 9.859×10^{-4} N
(3) 6.28×10^{-3} N
(4) 0.0314 N

169. **Statement I:** A cyclist is moving on an unbanked road with a speed of 7 kmh^{-1} and takes a sharp circular turn along a path of radius of 2m without reducing the speed. The static friction coefficient is 0.2. The cyclist will not slip and pass the curve. ($g = 9.8$ m/s²)
Statement II: If the road is banked at an angle of 45°, cyclist can cross the curve of 2m radius with the speed of 18.5 kmh^{-1} without slipping.
In the light of the above statements, choose the correct answer from the options given below.

[March 16, 2021 (II); 2002 (S)]

(1) Statement I is correct and statement II is incorrect
(2) Statement I is incorrect and statement II is correct
(3) Both statement I and statement II are true
(4) Both statement I and statement II are false

170. A small bob tied at one end of a thin string of length 1 m is describing a vertical circle so that the maximum and minimum tension in the string are in the ratio 5 : 1. The velocity of the bob at the highest position is _________ m/s. (Take $g = 10$ m/s²)

[Feb. 25, 2021 (I)]

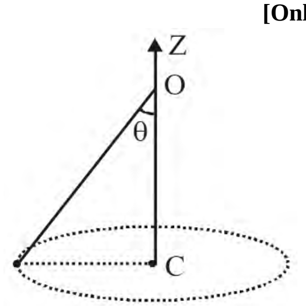
171. A disc rotates about its axis of symmetry in a hoizontal plane at a steady rate of 3.5 revolutions per second. A coin placed at a distance of 1.25 cm from the axis of rotation remains at rest on the disc. The coefficient of friction between the coin and the disc is ($g = 10$ m/s²)

[Online April 15, 2018]

(1) 0.5 (2) 0.7
(3) 0.3 (4) 0.6

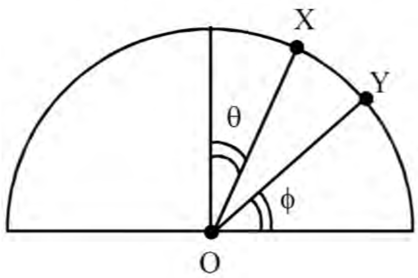
172. A conical pendulum of length 1 m makes an angle θ = 45° w.r.t. Z-axis and moves in a circle in the XY plane. The radius of the circle is 0.4 m and its centre is vertically be-low O. The speed of the pendulum, in its circular path, will be:
(Take $g = 10$ ms⁻²)

[Online April 9, 2017]



(1) 0.4 m/s
(2) 4 m/s
(3) 0.2 m/s
(4) 2 m/s

173. A particle is released on a vertical smooth semicircular track from point X so that OX makes angle θ from the vertical (see figure). The normal reaction of the track on the particle vanishes at point Y where OY makes angle ϕ with the horizontal. Then: **[Online April 19, 2014]**



(1) $\sin\phi = \cos\phi$ (2) $\sin\phi = \frac{1}{2}\cos\theta$

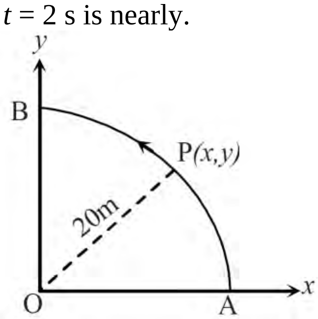
(3) $\sin\phi = \frac{2}{3}\cos\theta$ (4) $\sin\phi = \frac{3}{4}\cos\theta$

174. A body of mass 'm' is tied to one end of a spring and whirled round in a horizontal plane with a constant angular velocity. The elongation in the spring is 1 cm. If the angular velocity is doubled, the elongation in the spring is 5 cm. The original length of the spring is:

[Online April 23, 2013]

(1) 15 cm (2) 12 cm
(3) 16 cm (4) 10 cm

175. A point P moves in counter-clockwise direction on a circular path as shown in the figure. The movement of 'P' is such that it sweeps out a length $s = t^3 + 5$, where s is in metres and t is in seconds. The radius of the path is 20 m. The acceleration of 'P' when t = 2 s is nearly. **[2010]**



(1) 13 m/s^2 (2) 12 m/s^2
(3) 7.2 m/s^2 (4) 14 m/s^2

176. For a particle in uniform circular motion, the acceleration $\vec{a}$ at a point P(R,θ) on the circle of radius R is (Here θ is measured from the x-axis)

[June 25, 2022 (II)]

(1) $-\frac{v^2}{R}\cos\theta\hat{i} + \frac{v^2}{R}\sin\theta\hat{j}$

(2) $-\frac{v^2}{R}\sin\theta\hat{i} + \frac{v^2}{R}\cos\theta\hat{j}$

(3) $-\frac{v^2}{R}\cos\theta\hat{i} - \frac{v^2}{R}\sin\theta\hat{j}$

(4) $\frac{v^2}{R}\hat{i} + \frac{v^2}{R}\hat{j}$

177. An annular ring with inner and outer radii R_1 and R_2 is rolling without slipping with a uniform angular speed. The ratio of the forces experienced by the two particles situated on the inner and outer parts of the ring, F_1/F_2 is **[2005]**

(1) $(R_1/R_2)^2$ (2) R_2/R_1
(3) R_1/R_2 (4) 1

178. Which of the following statements is FALSE for a particle moving in a circle with a constant angular speed?

[2004]

(1) The acceleration vector points to the centre of the circle
(2) The acceleration vector is tangent to the circle
(3) The velocity vector is tangent to the circle
(4) The velocity and acceleration vectors are perpendicular to each other

Answer Key

1. (4)
2. (2)
3. (3)
4. (3)
5. (5)
6. (1)
7. (2)
8. (1)
9. (4)
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171. (4)
172. (4)
173. (3)
174. (1)
175. (4)
176. (3)
177. (3)
178. (2)

Solution

1. (4)

Sol. F = M × a (Force acting on body)

Given: $v = 4\sqrt{x}$

Squaring on both side, $v^2 = 16x$

Differentiating on both side w.r.t. x,

$$2v\frac{dv}{dx} = 16 \Rightarrow a = \frac{vdv}{dx} = \frac{16}{2} = 8 \text{ m/s}^2$$

$\therefore$ F = 0.5 × 8 = 4 N.

2. (2)

Sol. Given mass m = 2 kg, force F = 6 N along positive z-axis.

$$\therefore \text{ Acceleration } \vec{a} = 3\hat{k},\ t = \frac{5}{3}s$$

$$\vec{u} = 3\hat{i} + 4\hat{j}$$

$$\therefore\ \vec{v} = \vec{u} + \vec{a}t = 3\hat{i} + 4\hat{j} + 3\hat{k} \times \frac{5}{3} = 3\hat{i} + 4\hat{j} + 5\hat{k}$$

3. (3)

Sol. The problem involves the buoyancy force F acting on a balloon and change in its motion when a small mass is released. From Newton's second Law of Motion.

$$\text{F} - \text{M}g = \text{M}a$$

$$\Rightarrow\ \text{F} = \text{M}a + \text{M}g \qquad \ldots\text{(i)}$$

$$\text{F} - (\text{M} - x)g = (\text{M} - x)3a$$

$$\Rightarrow\ \text{M}a + \text{M}g - \text{M}g + xg = 3\text{M}a - 3xa \qquad \text{[using (i)]}$$

$$\Rightarrow\ x = \frac{2\text{M}a}{g + 3a}$$

4. (3)

Sol. Given,

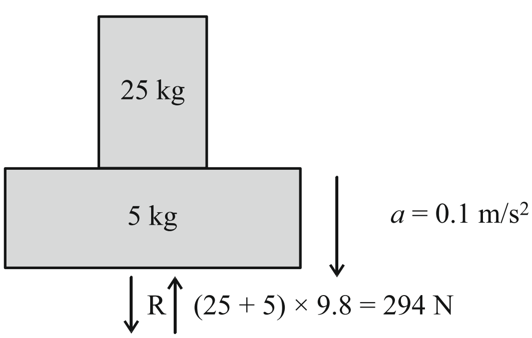
Mass of cricket ball, m = 150g

Speed of cricket ball, V = 20 m/s

$$\text{Force, } \text{F} = \frac{\Delta\text{P}}{\Delta t} = \frac{(mv - 0)}{0.1} = \frac{150 \times 20}{1000 \times 0.1} = 30 \text{ N}$$

5. (5)

Sol.



By Newton's 2nd law, $\text{F}_{\text{net}} = ma$

$\Rightarrow$ 294 – R = 30 (0.1) $\therefore$ R = 291 N

6. (1)

Sol. $\vec{P} = \cos(kt)\hat{i} - \sin(kt)\hat{j}$

$$\therefore\ \vec{F} = \frac{d\vec{P}}{dt} = -k\sin(kt)\hat{i} - k\cos(kt)\hat{j}$$

$$\cos\theta = \frac{\vec{F}\cdot\vec{P}}{|\vec{F}|\cdot|\vec{P}|} = \frac{-k\cos(kt)\cdot\sin(kt) + k\sin(kt)\cdot\cos(kt)}{1 \times k} = 0$$

$$\therefore \theta = \frac{\pi}{2}$$

7. (2)

Sol. Here force applied on the block increases linearly with time, so

$$F = ma \Rightarrow a = \frac{F}{m} = \frac{kt}{m} \text{ or } a \propto t$$

Hence a vs t graph will be a straight line passing through origin.

8. (1)

Sol. Using Newton's IInd law, $F = \frac{\Delta p}{\Delta t} = \frac{mv}{t}$

$$F = \frac{0.12 \times 25}{0.1} = 30\text{N}$$

9. (4)

Sol. Impulse, $I = \Delta P = P_f - P_i = m(v_f - v_i)$ $(\because v = \sqrt{2gh})$

Mass of body, m = 0.1 kg

$$I = \Delta P = 0.1\left(\sqrt{2 \times 9.8 \times 5} - \left(-\sqrt{2 \times 9.8 \times 10}\right)\right)$$

$$= 0.1(14 + 7\sqrt{2}) \approx 2.39 \text{ kg ms}^{-1}$$

10. (4)

Sol. From principle of momentum conservation,

$m_1v_1 = m_2v_2$

or, 1000 × 6 = 1200 × v = 5 m/s

11. (2)

Sol. By momentum conservation,

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

$$0 = 3(-v) + 0.01(600 - v)$$

$$v \approx 2\text{m/s}$$

12. (1)

Sol. Given,

Mass of the particle, m = 5 kg

As the particle is at rest, So resultant of $\vec{F_2}$ and $\vec{F_3}$ should be opposite to $\vec{F_1}$

$$F_{net} = \sqrt{F_2^2 + F_3^2} = \sqrt{6^2 + 8^2} = 10N$$

$$\therefore\ \text{Acceleration, } a = \frac{F_{net}}{m} = \frac{10}{5} = 2\text{m/s}^2$$

13. (2)

Sol. Given, mass of each bullets, m = 10g

Speed of each bullets, v = 250 m/s

Force $F = n\,m\,v$

Here n = number of bullets fired per second

$$\therefore \; n = \frac{F}{mv} = \frac{125}{10 \times 10^{-3} \times 250} = 50$$

14. (2)

Sol. Given,

Mass of body, $m = \frac{500}{1000} = 0.5\text{kg}$

Velocity, $v = 10\sqrt{x} \Rightarrow v^2 = 100x$

$\therefore \; 2v\frac{dv}{dx} = 100 \Rightarrow a = \frac{vdv}{dx} = 50 \text{ m/s}^2$

$\therefore$ Force, $F = ma = 0.5 \times 50 = 25$ N

15. (1)

Sol. Mass of particle,

$m = 500g = 0.5kg$

Velocity of a particle,

$\vec{v} = 2t\hat{i} + 3t^2\hat{j}$

$\vec{a} = \frac{d\vec{v}}{dt} = 2\hat{i} + 6t\hat{j}$

at $t = 1$s, $\vec{a} = 2\hat{i} + 6\hat{j}$

Force acting on the particle,

$\vec{F} = m\vec{a} = 0.5(2\hat{i} + 6\hat{j}) = \hat{i} + 3\hat{j}$

$\vec{F} = \hat{i} + x\hat{j}$ Hence x = 3

16. (2)

Sol. We have, Impulse = Area under F-t curve, for fig (D), area is highest. So, impulse is maximum,

17. (3)

Sol. $\left|\frac{d\vec{p}}{dt}\right| = |\vec{F}| =$ Slop of curve

As, shown in figure maximum slope represent (c) and minimum slope represent (b).

18. (4)

Sol. Given, mass of machine gun, M = 10 kg

mass of bullet, m = 20g = 20 × 10^{-3} kg

velocity of bullet V = 100 ms^{-1}, let V be the recoil velocity of gun, using conservation of momentum

nmv = MV

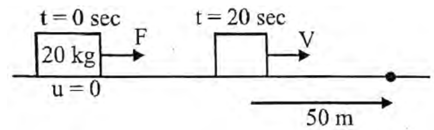
$$\Rightarrow 20 \times 10^{-3} \times \frac{180}{60} \times 100 = 10V$$

$\because$ n = 180 bullets per minute

$\Rightarrow$ v = 0.6 m/s

19. (2)

Sol.



Assume surface to be frictionless

Then, 50 = V × 10 $\Rightarrow V$ = 5 m/s

As $v = u + at \Rightarrow V = 0 + a \times 20$

$\Rightarrow 5 = a \times 20 \Rightarrow a = \frac{1}{4}$ m/s^2

So, $F = ma = 20 \times \frac{1}{4} = 5\text{N}$

20. (2)

Sol. Impulse, I = change in momentum, ΔP

$F_{avg} = \frac{\Delta P}{\Delta t} \because \Delta P_1 = \Delta P_2 \; \therefore I_1 = I_2$

Given Δt_1 = 3s and Δt_2 = 5s

Hence, F_{avg} in case (i), when Δt_2 = 3s is more than (ii) when Δt_2 = 5s

21. (2)

Sol. Force, $F = \frac{dm}{dt}v = \frac{10}{5} \times 4.5 = 9$ dyne

22. (2)

Sol. Initial momentum $\vec{P}_i = 0.15 \times 12(\hat{i})$

Final momentum $\vec{P}_f = 0.15 \times 12(-\hat{i})$

$|\Delta\vec{P}| = 3.6$ kg m/s or, 3.6 = FΔt

3.6 = 100 Δt $\therefore$ Δt = 0.036 sec

23. (3)

Sol. $F = \frac{dp}{dt} = v\frac{dm}{dt} = 10 \times 1 = 10\text{N}$

$a = \frac{F}{m} = \frac{10}{2} = 5 \text{ m/s}^2$

24. (6)

Sol. By law of conservation of linear momentum $\vec{P_i} = \vec{P_f}$

$\Rightarrow 60 \times \text{V} = (120 + 60) \times 2 \Rightarrow 60\text{V} = 360 \Rightarrow \text{V} = 6$ m/s

25. (3)

Sol. $a = \frac{vdv}{dx}; adx = vdx; \int_{0.5}^{1.5} -\frac{kx}{m}dx = \int_4^v vdv$

$\Rightarrow -\frac{k}{2m}[1.5^2 - 0.5^2] = \frac{v^2 - 4^2}{2} \Rightarrow -\frac{12}{2 \times 2}[2] = \frac{v^2 - 16}{2}$

$\Rightarrow -3 \times 4 = v^2 - 16 \Rightarrow v^2 = 4 \Rightarrow v = 2$ m/s

26. (12)

Sol. $= P_f - P_i = mv - (-mv) = 2mv = 2\times 0.4\times 15 = 12$ Ns

27. (2)

Sol. $\vec{F} = 10\hat{i} + 5\hat{j}; m = 0.1$ kg

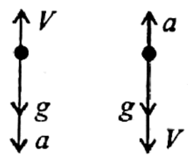
$$\vec{a} = \frac{\vec{F}}{m} = \frac{10\hat{i} + 5\hat{j}}{0.1} = 100\hat{i} + 50\hat{j}$$

$$\vec{S} = \vec{u}t + \frac{1}{2}\vec{a}t^2 = 0 + \frac{1}{2}(100\hat{i} + 50\hat{j})\times 2^2 = 200\hat{i} + 100\hat{j}$$

28. (2)

Sol. While going upward, $a_1 = -(g + a)$

$$= -\left(10 + \frac{10}{5}\right) = -12 \text{ m/s}^2$$



Now, $V = u + a_1t_1 \Rightarrow u = -a_1t_1$

and, $S = ut_1 + \frac{1}{2}at_1^2$

$$S = ut_1 - \frac{1}{2}\times 12\times t_1^2$$

$$= -at_1^2 - 6t_1^2 = 12t_1^2 - 6t_1^2 = 6t_1^2$$

$$a_2 = g - a = 10 - \frac{10}{5} = 8 \text{ m/s}^2$$

Here, $u = 0$

So, $S = \frac{1}{2}a_2t_2^2 = \frac{1}{2}\times 8\times t_2^2 = 4t_2^2$

So, $S = 6t_1^2 = 4t_2^2 \Rightarrow \frac{t_1}{t_2} = \sqrt{\frac{4}{6}} = \sqrt{\frac{2}{3}}$

29. (4)

Sol. Thrust force on rocket is given by

$$F_{\text{thrust}} = \left(V_{rel}\cdot\frac{dm}{dt}\right)$$

$$\Rightarrow \left(V_{rel}\cdot\frac{dm}{dt} - mg\right) = ma$$

$$\Rightarrow 500\left(\frac{dm}{dt}\right) - 10^3\times 10 = 10^3\times 20$$

$$\Rightarrow \frac{dm}{dt} = 60 \text{ kg/s}$$

30. (3)

Sol. From the Newton's second law of motion,

F = ma

$$\Rightarrow a = \frac{F}{M} \Rightarrow a = \frac{F_0}{M}\left[1 - \left(\frac{T-t}{T}\right)^2\right]$$

$$\Rightarrow a = \frac{dv}{dt} = \frac{F_0}{M}\left[1 - \left(\frac{T-t}{T}\right)^2\right]$$

$$\Rightarrow \int_0^v dv = \frac{F_0}{M}\int_0^{2T}\left[1 - \left(\frac{T-t}{T}\right)^2\right]dt$$

$$\Rightarrow v = \frac{F_0}{M}\left[t + \frac{1}{3T^2}(T-t)^3\right]_0^{2T}$$

$$\Rightarrow v = \frac{F_0}{M}\left\{\left[2T + \frac{1}{3T^2}(T-2T)^3\right] - \left[0 + \frac{T^3}{3T^2}\right]\right\}$$

$$\Rightarrow v = \frac{F_0}{M}\left[\frac{4T}{3}\right] = \frac{4F_0T}{3M}$$

31. (3)

Sol. Acceleration, $\vec{a} = \frac{\vec{F}}{m} = \frac{40\hat{i} + 10\hat{j}}{5} = 8\hat{i} + 2\hat{j}$ m/s^2

Using,

$$\Rightarrow \vec{s} = \vec{u}t + \frac{1}{2}\vec{a}t^2 \Rightarrow \vec{s} = \frac{1}{2}(8\hat{i} + 2\hat{j})\times 100$$

$$\Rightarrow \vec{s} = (400\hat{i} + 100\hat{j}) \text{ m}$$

32. (500)

Sol. $\vec{a} = \frac{\vec{F}}{m} = 10\hat{i} + 5\hat{j}$

Displacement of the box along x-axis,

$$x = \frac{1}{2}a_xt^2 = \frac{1}{2}\times 10\times 100 = 500 \text{ m}$$

33. (1)

Sol. Given

$$\vec{F} = k(v_y\hat{i} + v_x\hat{j})$$

$$\therefore F_x = kv_y, F_y = kv_x$$

$$m\frac{dv_x}{dt} = kv_y \Rightarrow \frac{dv_x}{dt} = \frac{k}{m}v_y$$

Similarly, $\frac{dv_y}{dt} = \frac{k}{m}v_x$

$$\frac{dv_y}{dv_x} = \frac{v_x}{v_y} \Rightarrow \int v_ydv_y = \int v_xdv_x$$

$$v_y^2 = v_x^2 + C$$

$$\Rightarrow v_y^2 - v_x^2 = \text{ constant } C_0 \text{ (let)}$$

$$\vec{v} \times \vec{a} = (v_x\hat{i} + v_y\hat{j}) \times \frac{k}{m}(v_y\hat{i} + v_x\hat{j})$$

$$= (v_x^2\hat{k} - v_y^2\hat{k})\frac{k}{m} = (v_x^2 - v_y^2)\frac{k}{m}\hat{k} = \frac{C_0 k}{m}\hat{k} = \text{constant}$$

34. (2)

Sol. From the Newton's second law,

$$F = \frac{dp}{dt} = \frac{d(mv)}{dt} = v\left(\frac{dm}{dt}\right) \qquad \ldots\text{(i)}$$

We have given, $\frac{dM(t)}{dt} = bv^2(t) \qquad \ldots\text{(ii)}$

Thrust on the satellite,

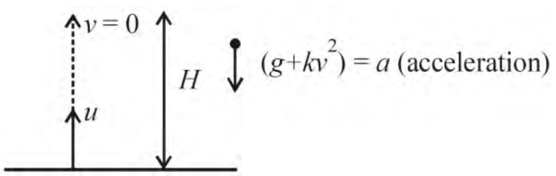
$$F = v_{rel}\left(\frac{dm}{dt}\right) = (0 - v)\left(\frac{dM}{dt}\right) = -v(bv^2) = -bv^3$$

[Using (i) and (ii)]

$$\Rightarrow F = M(t)a = -bv^3 \Rightarrow a = \frac{-bv^3}{M(t)}$$

35. (4)

Sol.



F = $-mkv^2 - mg$

($\because$ mg and mkv^2 act in downward direction)

$$a = \frac{F}{m} = -[kv^2 + g]$$

$$\Rightarrow v \cdot \frac{dv}{dh} = -[kv^2 + g] \qquad \left(\because a = v\frac{dv}{dh}\right)$$

$$\Rightarrow \int_u^0 \frac{v \cdot dv}{kv^2 + g} = \int_0^h dh \Rightarrow \frac{1}{2k}\ln[kv^2 + g]_u^0 = -h$$

$$\Rightarrow \frac{1}{2k}\ln\left[\frac{ku^2 + g}{g}\right] = h \Rightarrow h = \frac{1}{2k}\ln\left[\frac{ku^2}{g} + 1\right]$$

36. (1)

Sol. Net acceleration

$$\frac{dv}{dt} = a = -(g + \gamma v^2)$$

Let time t required to rise to its zenith ($v = 0$) so,

$$\int_{v_0}^0 \frac{-dv}{g + \gamma v^2} = \int_0^t dt \qquad [\text{for } H_{max}, v = 0]$$

$$\Rightarrow \frac{1}{\gamma}\int_{v_0}^0 \frac{-1}{\left(\sqrt{\frac{g}{\gamma}}\right)^2 + v^2} dv = t$$

$$\Rightarrow \frac{1}{\gamma} \cdot \frac{1}{\sqrt{\frac{g}{\gamma}}}\left[\tan^{-1}\left(\frac{v}{\sqrt{\frac{g}{\gamma}}}\right)\right]_{v_0}^0 = -t$$

$$\Rightarrow \frac{-1}{\sqrt{\gamma g}}\tan^{-1}\left(\frac{\sqrt{\gamma}}{\sqrt{g}}v_0\right) = -t$$

$$\therefore t = \frac{1}{\sqrt{\gamma g}}\tan^{-1}\left(\frac{\sqrt{\gamma}v_0}{\sqrt{g}}\right)$$

37. (4)

Sol. $v^2 = u^2 - 2gh$ or $v = \sqrt{u^2 - gh}$

Momentum, $P = mv = m\sqrt{u^2 - 2gh}$

At $h = 0$, P = ± mu and at $h = \frac{u^2}{2g}$, P = 0

upward direction is positive and downward direction is negative.

38. (2)

Sol. From Newton's second law

$$\frac{dp}{dt} = F = kt$$

Integrating both sides we get,

$$\int_p^{3p} dp = \int_0^T kt\, dt \Rightarrow [p]_p^{3p} = k\left[\frac{t^2}{2}\right]_0^T$$

$$\Rightarrow 2p = \frac{kT^2}{2} \Rightarrow T = 2\sqrt{\frac{p}{k}}$$

39. (1)

Sol. From $F = \frac{R}{t^2}v(t) \Rightarrow m\frac{dv}{dt} = \frac{R}{t^2}v(t)$

Integrating both sides $\int \frac{dv}{v(t)} = \int \frac{R dt}{mt^2}$

$$\text{In } v(t) = -\frac{R}{mt}$$

$$\therefore \ln\ \ln v(t) \propto \frac{1}{t}$$

40. (1)

Sol. From question,

Mass of body, $m = 5$ kg

Velocity at $t = 0$,

$\vec{u} = (6\hat{i} - 2\hat{j})$ m/s

Velocity at $t = 10$ s,

$\vec{v} = +6\hat{j}$ m/s

Force, F = ?

Acceleration, $\vec{a} = \dfrac{\vec{v} - \vec{u}}{t} = \dfrac{6\hat{j} - (6\hat{i} - 2\hat{j})}{10}$

$= \dfrac{-3\hat{i} + 4\hat{j}}{5} = \dfrac{-3\hat{i} + 4\hat{j}}{5}$ m/s^2

Force, $\vec{F} = m\vec{a} = 5 \times \dfrac{(-3\hat{i} + 4\hat{j})}{5} = (-3\hat{i} + 4\hat{j})$ N

41. (3)

Sol. Given that $F(t) = F_0 e^{-bt} \Rightarrow m\dfrac{dv}{dt} = F_0 e^{-bt}$

$$\frac{dv}{dt} = \frac{F_0}{m} e^{-bt}$$

$$\int_0^v dv = \frac{F_0}{m}\int_0^t e^{-bt} dt$$

$$v = \frac{F_0}{m}\left[\frac{e^{-bt}}{-b}\right]_0^t = \frac{F_0}{mb}\left[-(e^{-bt} - e^{-0})\right]$$

$$\Rightarrow v = \frac{F_0}{mb}[1 - e^{-bt}]$$

42. (3)

Sol. If you push a cart with some force then according to Newton third law the cart will exert an equal and opposite force on you. So the cart push you with same amount of force in opposite direction. So Statement 1 is correct. The action reaction pairs mentioned in statement one cannot cancel each other because action and reaction forces act on two different bodies. So they cannot cancel each other. So Statement 2 is wrong.

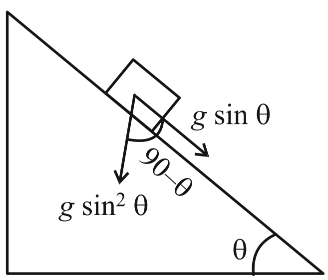
43. (4)

Sol. $mg \sin\theta = ma$

$\therefore a = g\sin\theta$

$\therefore$ Vertical component of acceleration $= a\sin\theta$

$= g\sin^2\theta$



$\therefore$ Relative vertical acceleration of A with respect to B is

$$g(\sin^2 60 - \sin^2 30) = g\left(\frac{3}{4} - \frac{1}{4}\right) = \frac{g}{2} = 4.9 \text{ m/s}^2$$

In vertical direction

44. (4)

Sol. For the motion of ball, just after the throwing

$v = 0$, $s = 2$m, $a = -g = -10$ ms^{-2}

$\Rightarrow -u^2 = 2(-10) \times 2u^2 = 40$

When the ball is in the hands of the thrower

$u = 0, v = \sqrt{40}$ ms^{-1}

$s = 0.2$ m

$v^2 - u^2 = 2as$

$\Rightarrow 40 - 0 = 2\,(a)\,0.2 \Rightarrow a = 100$ m/s^2

$\therefore$ F = ma = 0.2 × 100 = 20 N

$\Rightarrow$ N – mg = 20 $\Rightarrow$ N = 20 + 2 = 22N

Note:

$W_{hand} + W_{gravity} = \Delta K$

$\Rightarrow$ F(0.2) – (0.2)(10)(2.2) = 0 $\Rightarrow$ F = 22 N

45. (3)

Sol. Given, mass of cricket ball, $m = 150\ g = 0.15$ kg

Initial velocity, $u = 20$m / s

Force,

$$F = \frac{m(u - v)}{t} = \frac{0.15(20 - 0)}{0.1} = 30\text{N}$$

46. (3)

Sol. Mass (m) = 0.2 kg

$\Rightarrow ma = -15x \Rightarrow 0.3a = -15x$

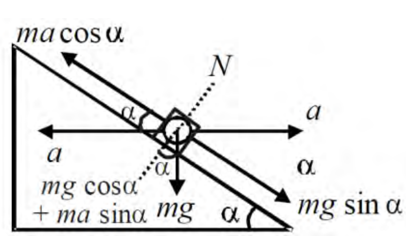
$\Rightarrow a = -\dfrac{15}{0.3}x = \dfrac{-150}{3}x = -50x$

At $x = 0.2$m, $a = -50 \times 0.2 = -10$ m/s^2 (towards origin)

$\therefore$ a = 10 m/s^2 (away from origin)

47. (3)

Sol. When the incline is given an acceleration a towards the right, the block experience a pseudo force ma towards left.

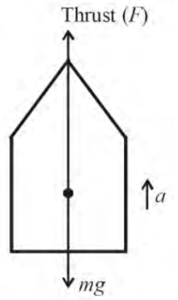


For block to remain stationary, Net force along the incline should be zero.

$mg\sin\alpha = ma\cos\alpha \Rightarrow \alpha = g\tan\alpha$

48. (2)

Sol. In the absence of air resistance, if the rocket moves up with an acceleration a, then thrust



F = $mg + ma$

$\therefore$ F = $m(g + a) = 3.5 \times 10^4\,(10 + 10)$

= 7×10^5 N

49. (4)

Sol. Resultant force is zero, as three forces are represented by the sides of a triangle taken in the same order. From Newton's second law, $\vec{F}_{net} = m\vec{a}$.

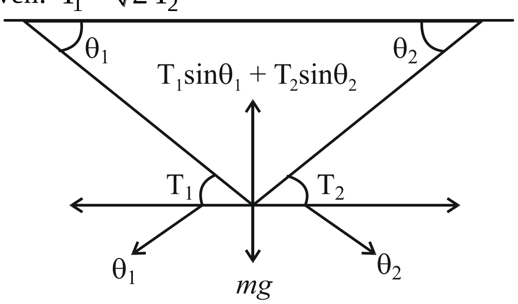
Therefore, acceleration is also zero i.e., velocity remains unchanged.

50. (4)

Sol. This is a case of sliding (if plane is frictionless) and therefore the acceleration of all the bodies is same.

51. (2)

Sol. Given: $T_1 = \sqrt{2}T_2$



$T_1 \sin\theta_1 + T_2 \sin\theta_2 = mg$ and $T_1 = \sqrt{3}T_2$

$\Rightarrow T_2\left[\sqrt{3}\sin\theta_1 + \sin\theta_2\right] = mg$

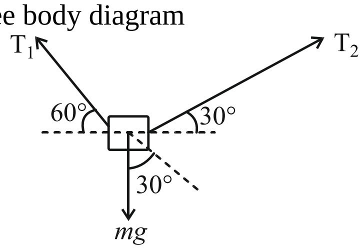
From the option,

For $\theta_1 = 60°$ and $\theta_2 = 30°$

$\therefore T_2 = \dfrac{mg}{2}$

52. (2)

Sol. Using free body diagram



$T_1 = mg\cos 30°$

$= 1 \times 10 \times \dfrac{\sqrt{3}}{2} = 5\sqrt{3}$

$T_2 = mg\sin 30° = 1 \times 10 \times \dfrac{1}{2} = 5$

53. (3)

Sol. For massless spring, F = kx

$\therefore kx_1 = 5$N

$\therefore kx_2 = 7$N

$\therefore k(5x_1 - 2x_2)\ 5kx_1 - 2kx_2$

= 5 × 5 – 2 × 7 = 11N

54. (1)

Sol. Acceleration of the system is given by

$a = \left(\dfrac{m_2 - m_1}{m_1 + m_2}\right)g = \dfrac{g}{8}$

$\Rightarrow 8(m_2 - m_1) = m_1 + m_2 \Rightarrow 7m_2 = 9m_1$

$\Rightarrow \dfrac{m_2}{m_1} = \dfrac{9}{7}$

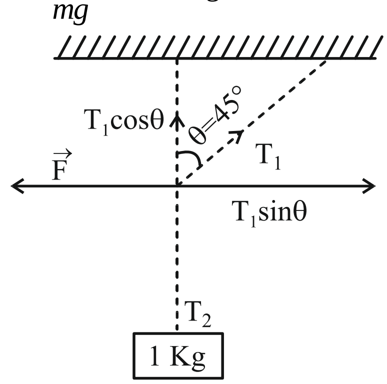
55. (4)

Sol. From the free body diagram

$T_1 \sin 45° = F$

$T_1 \cos 45° = T_2 = mg$

$\therefore \tan 45° = \dfrac{F}{mg} \Rightarrow F = mg$



$\Rightarrow$ F = 1 × 10 = 10 N (∵ m = 1 kg)

56. (1)

Sol. Acceleration is given as:

$a = \left(\dfrac{m_2 - m_1}{m_1 + m_2}\right)g$

$\Rightarrow \dfrac{g}{\sqrt{2}} = \left(\dfrac{m_2 - m_1}{m_1 + m_2}\right)g$

$\Rightarrow \sqrt{2}(m_2 - m_1) = m_1 + m_2$

$\Rightarrow \dfrac{m_1}{m_2} = \left(\dfrac{\sqrt{2} - 1}{\sqrt{2} + 1}\right)$

57. (240)

Sol. Taking masses M_1, M_2 and M_3 as system, $\therefore$ $F_{net} = ma$

$\Rightarrow T_1 - (4 + 6 + 10) \times 10 = (4 + 6 + 10) \times (2)$

$\therefore T_1 = 20(10 + 2) = 240$ N

58. (4)

Sol. For 2 kg block

$T - 2g \sin 30 = 2a$ …(i)

$\because$ $T = g + 2a$

For 4 kg block

$4g - 2T = 4a$

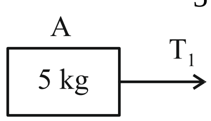
$\Rightarrow 4g - 2(g + 2a) = 4a$

$\therefore a = \dfrac{g}{4}$

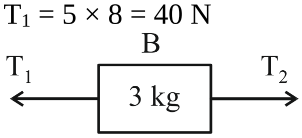
59. (1)

Sol. Horizontal force, F = 80 N

$$a_A = a_B = a_C = \frac{F}{5+3+2} = \frac{80}{10} = 8 \text{m/s}^2$$



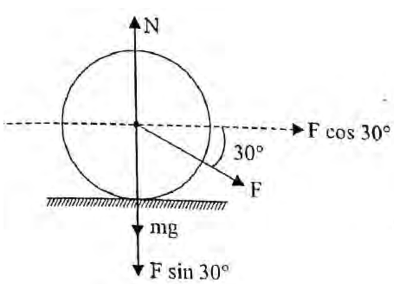
$T_1 = 5 \times 8 = 40$ N



$T_2 - T_1 = 3 \times 8 \Rightarrow T_2 = 64$ N

60. (3)

Sol.

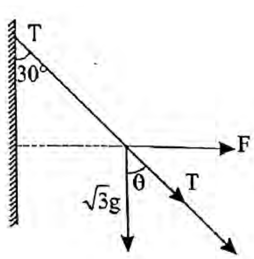


From FBD of roller

$N = mg + F \sin 30° = 700 + 200 \times \dfrac{1}{2} = 800$ N

61. (1)

Sol.



From the free body diagram shown above,

$$\cos\theta = \frac{\sqrt{3}g}{T} \qquad \therefore \theta = 30° \qquad \therefore \frac{\sqrt{3}}{2} = \frac{\sqrt{3}g}{T}$$

$\Rightarrow$ T = 20 N

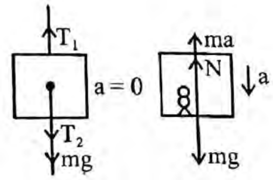
62. (2)

Sol. From FBD of lift,

$T_1 = T_2 + mg$, m = mass of lift

$\Rightarrow T_1 - T_2 = mg$

$\Rightarrow T_{net} = mg$.



So, (I) is true

From FBD of person,

$N + ma = mg$

$N = mg - ma \Rightarrow N < mg$

So, (II) is false.

63. (2)

Sol. For 4 kg block

$4g \sin 30° - T = 4a$ …(i)

For 1 kg block

$T - 1g \sin 30° = 1a$

$4(T - g \sin 30°) = 4a$ …(ii)

From (i) from (ii), we get

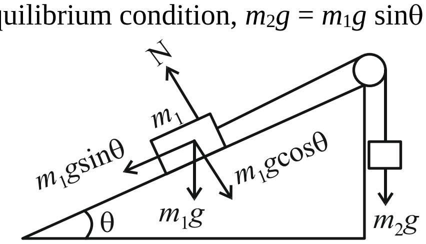
$4(T - g \sin 30°) = 4g \sin 60° - T$

$5T = 20\sqrt{3} + 20$

$T = 4(\sqrt{3} + 1)$N

64. (2)

Sol. For equilibrium condition, $m_2g = m_1g \sin\theta$



$$\sin\theta = \frac{m_2}{m_1} = \frac{3}{5}$$

$$\cos\theta = \frac{4}{5}$$

Normal force (N) on $m_1 = 5g \cos\theta$

$$= 5 \times 10 \times \frac{4}{5} = 40\text{N}$$

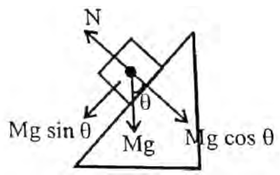
65. (3)

Sol. Acceleration of block on smooth inclined plane,

$a = g \sin\theta$

Using, $s = ut + \frac{1}{2}at^2$

$$s = \frac{1}{2} g \sin 30°(2)^2$$



When the incline is changed to 45°

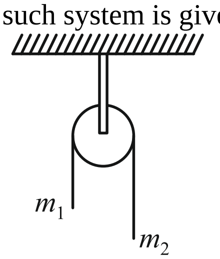
$$s = \frac{1}{2} g \sin 45° t^2$$

As distance travelled ins same

$$\therefore \left(\frac{1}{2}\right)(4) = \frac{1}{\sqrt{2}} t^2 \Rightarrow t = \sqrt{2\sqrt{2}} \approx 1.68$$

66. (4)

Sol. Acceleration in such system is given as



$$a = \frac{(m_2 - m_1)}{(m_2 + m_1)} g$$

$$\Rightarrow \frac{g}{2} = \frac{(\lambda(L-\ell) - \lambda\ell)g}{\lambda L} \Rightarrow \ell = \frac{L}{4} = \frac{L}{x}$$

So, $x = 4$

67. (3)

Sol. Given that mass of monkey, $m = 50$kg

Acceleration due to gravity, $g = 10$ m/s^2

Tension (T) = 350N

Given monkey climbs downward, acceleration of monkey, $a = 4$ m/s^2

When monkey climbs upward, acceleration of monkey, $a = 5$ m/s^2

(For upward)

$T - mg = ma \Rightarrow T = mg + ma = 50(10 + 5) = 750N$

Rope will break while climbing upward

(For downward)

$T = m(g - a) = 50(10 - 4) = 300N$

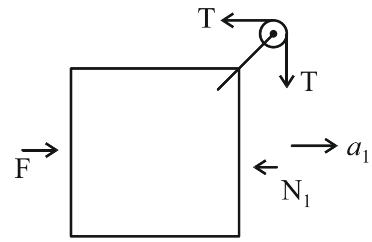
Rope will not break while climbing downward

68. (1)

Sol. Let a_1 be the acceleration of 100 kg block

FBD of 100 kg block w.r.t. ground

$F - T - N1 = 100\, a_1$ ....(i)

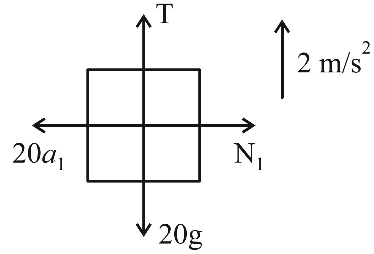


FBD of 20 kg block w.r.t. 100 kg

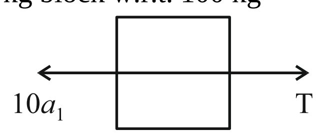
$T - 20\,g = 20(2) \Rightarrow T = 40 + 200$

$\Rightarrow T = 240$ ...(ii)

$N_1 = 20a_1$ ...(iii)



FBD of 10 kg block w.r.t. 100 kg



$$10a_1 - 240 = 10(2) \Rightarrow a_1 = 26 \text{ m/s}^2$$

$$F = 240 + 20(26) + 100 \times 26 \Rightarrow F = 3360 \text{ N}$$

69. (2)

Sol. $a = \dfrac{M_2 g - M_1 g}{M_1 + M_2}$

When, $M_2 = 2M_1 \Rightarrow a_1 = \dfrac{2M_1 g - M_1 g}{3M_1} = \dfrac{g}{3}$

When $M_2 = 3M_1 \Rightarrow a_2 = \dfrac{3M_1 g - M_1 g}{4M_1} = \dfrac{g}{2}$

The ratio $\dfrac{a_1}{a_2} = \dfrac{\frac{g}{3}}{\frac{g}{2}} = \dfrac{2}{3}$

70. (3)

Sol. Along horizontal

$F_1 + 1\cos 45° = 2\sin 45°$

$$F_1 = \frac{2}{\sqrt{2}} - \frac{1}{\sqrt{2}} = \frac{1}{\sqrt{2}}$$

Along vertical

$F_2 = 1\sin 45 + 2\sin 45$

$F_2 = 3\sin 45 = \dfrac{3}{\sqrt{2}}$ so, $\dfrac{F_1}{F_2} = \dfrac{1}{3} = \dfrac{1}{x}$ so, $x = 3$

71. (1)

Sol. Let addition force required be = $\vec{F}$

$\vec{F}+5\hat{i}-6\hat{i}+7\hat{j}-8\hat{j}=0$

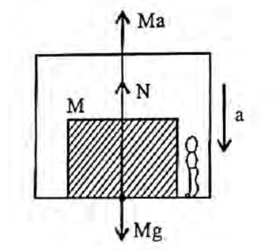
$\Rightarrow \vec{F}=\hat{i}+\hat{j}, |\vec{F}|=\sqrt{1^2+1^2}=\sqrt{2}\text{N}$

Angle with x-axis: $\tan\theta=\dfrac{y\text{ component}}{x\text{ component}}=\dfrac{1}{1}$

So, $\theta = \tan^{-1}(1) = 45°$

72. (3)

Sol. For observer in box



N + Ma = Mg

$\Rightarrow$ N = M(g – a)

$\Rightarrow \dfrac{Mg}{4}=M(g-a)\Rightarrow a=\dfrac{3g}{4}$

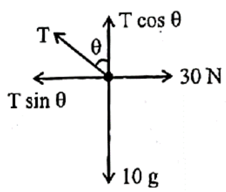
73. (3)

Sol. FBD of middle point is as shown below.

From FBD

T sin θ = 30

T cos θ = 100



So, tan θ = 0.3

= 3 × 10–1

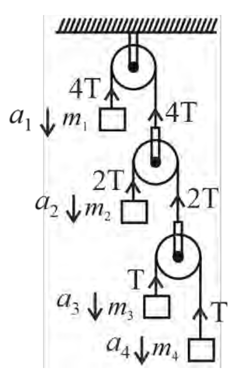
So, $\theta = \tan^{-1}(3\times10^{-1})$

74. (2)

Sol. When elevator moves downward, then a pseudo force acts on object in upward direction, due to which effective weight of object decreases.

75. (1)

Sol.



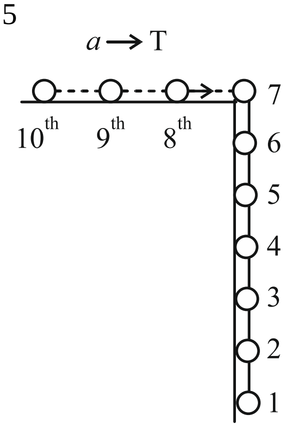
$\Rightarrow -4\text{T}a_1 - 2\text{T}a_2 - \text{T}a_3 - \text{T}a_4 = 0$

$\Rightarrow 4a_1 + 2a_2 + a_3 + a_4 = 0$

76. (36)

Sol. We have, acceleration of system as

$a=\dfrac{6mg}{10m}=\dfrac{3g}{5}$

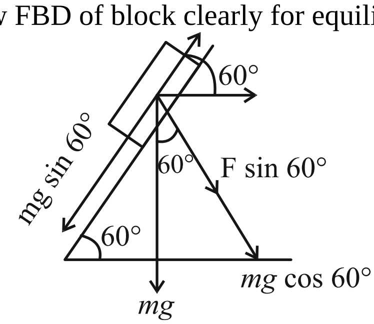


Taking 8, 9, 10 together

$\text{T}=3ma=3m\times\dfrac{3g}{5}=\dfrac{3\times2\times3\times10}{5}=36\text{N}$

77. (12)

Sol. Let draw FBD of block clearly for equilibrium



F cos 60° = mg sin 60°

$\Rightarrow \dfrac{\text{F}}{mg}=\tan 60°$

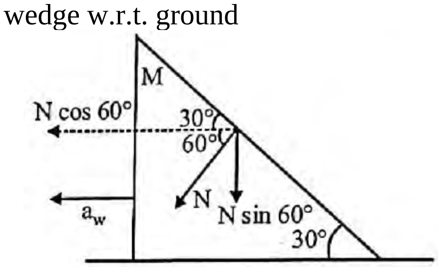
$\Rightarrow \dfrac{\sqrt{x}}{0.2\times10}=\sqrt{3}$

$\Rightarrow \sqrt{x}=2\sqrt{3}\Rightarrow x=12$

78. (4)

Sol. Let a_w be the acceleration of wedge and a_b be the acceleration of block w.r.t wedge

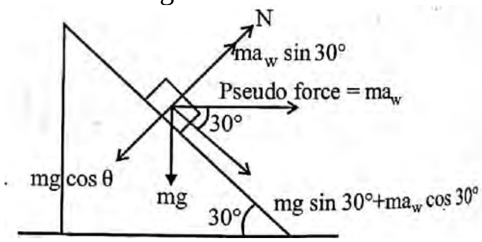
For the wedge w.r.t. ground



$$N\cos 60° = Ma_w \Rightarrow N \times \frac{1}{2} = 16a_w$$

$\Rightarrow$ N = 32 a_w …(i)

For block w.r.t. wedge



Balancing vertical forces

N + ma_w sin 30° = mg cos 30°

$\Rightarrow$ N = 8g cos30° – 8a_w sin 30°

$\Rightarrow$ $32a_w = 4\sqrt{3}g - 4a_w$ (Using (i))

$$\Rightarrow a_w = \frac{\sqrt{3}}{9}g$$

Along incline plane

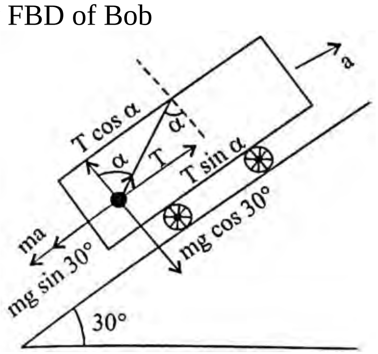
$$\Rightarrow mg\sin 30° + ma_w \cos 30° = ma_b = 8a_b$$

$$\Rightarrow a_b = \frac{8 \times g \times \frac{1}{2} + 8 \times \frac{\sqrt{3}}{9} \times g \times \frac{\sqrt{3}}{2}}{8}$$

$$\Rightarrow a_b = g \times \frac{1}{2} + \frac{\sqrt{3}}{9}g\frac{\sqrt{3}}{2} = \frac{2g}{3}$$

79. (30)

Sol. Let draw FBD of Bob



We have

T sin α = ma + mg sin 30° ….(i)

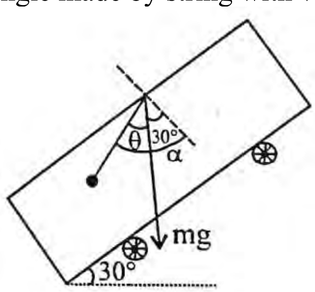
T cos α = mg cos 30° …(ii)

Dividing (i) by (ii), we get

$$\tan\alpha = \frac{a + g\sin 30°}{g\cos 30°} = \frac{10+5}{5\sqrt{3}} = \sqrt{3}$$

So, α = 60°

Let 'θ' be angle made by string with vertical



From diagram, α = θ + 30°

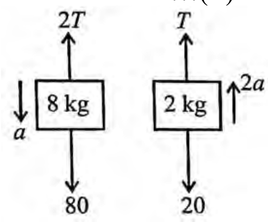
$\Rightarrow$ 60° = θ + 30° $\Rightarrow$ θ = 30°

80. (4)

Sol. From free body diagram

80 – 2T = 8a …(i)

T – 20 = 4a …(ii)



Multiply equation (ii) by 2 and adding with equation (i) we get

$$(8+8)a = 40 \Rightarrow a = \frac{40}{16} = \frac{10}{4}\ \text{m/s}^2$$

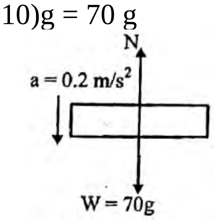
$$\text{Using } S = \frac{1}{2}at^2 \Rightarrow t^2 = \frac{2S}{a}$$

$$\Rightarrow \frac{0.2 \times 2 \times 4}{10} = t^2 \Rightarrow t = 0.4\ \text{sec}$$

81. (2)

Sol. Total weight acting downward,

W = (20 × 3 + 10)g = 70 g



Now from FBD,

W – N = 70a = 70 × 0.2

$\therefore$ N = 70 × 10 – 70 × 0.2 = 686 N

82. (82)

Sol. $\vec{P}$ makes angle of 35° with AC

So, component along AC = 100 cos 35 = 81.9 N $\simeq$ 82 N

83. (492)

Sol. Mass of the person, M = 60kg

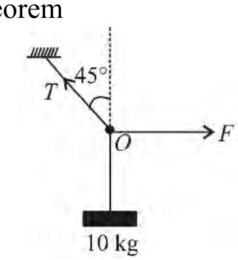
Tension in the rope of the lift when it moves downward with acceleration a,

T = M(g – a) = 60(10 – 1.8) = 492 N

84. (1)

Sol. The free body diagram is

By Lami's theorem

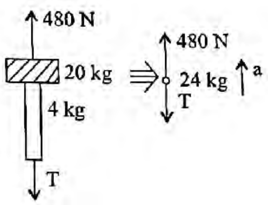


$\Rightarrow \dfrac{mg}{\sin 135°} = \dfrac{F}{\sin 135°}$

$\Rightarrow$ F = mg = 100 N

85. (4)

Sol. $a = \dfrac{480}{20+12+8} = 12\,\text{m/s}^2$



480 – T = 24a

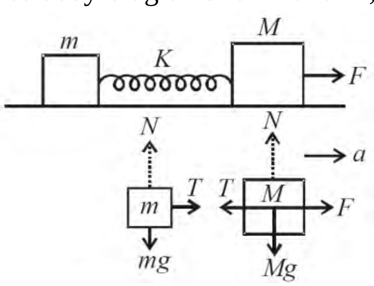
480 – T = 24 × 12

480 – T = 288

T = 192 N

86. (4)

Sol. Writing free body-diagrams for m and M,



we get T = ma and F–T= Ma

where T is force due to spring

$\Rightarrow$ F–ma–Ma or, F = Ma+ma

$\therefore$ Acceleration of the system

$a = \dfrac{F}{M+m}$

Now, force acting on the block of mass m is

$ma = m\left(\dfrac{F}{M+m}\right) = \dfrac{mF}{m+M}$

87. (3)

Sol. Here, m_1 = 5kg and m_2 = 4.8 kg.

If a is the acceleration of the masses,

$m_1a = m_1g - T$ …(i)

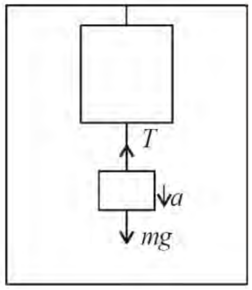
$m_2a = T - m_2g$ …(ii)

Solving (i) and (ii) we get

$a = \left(\dfrac{m_1 - m_2}{m_1 + m_2}\right)g \Rightarrow a = \dfrac{(5-4.8)\times 9.8}{(5+4.8)}\ \text{m/s}^2 = 0.2\ \text{m/s}^2$

88. (1)

Sol. When lift is stationary, $W_1 = mg$ …(i)



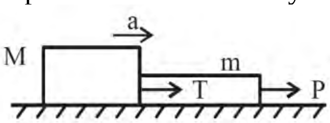
When the lift descends with acceleration, a

$W_2 = m(g - a)$

$W_2 = \dfrac{49}{9.8}(9.8-5) = 24\text{N}$

89. (4)

Sol. Taking the rope and the block as a system



we get P = (m + M)a

$\therefore$ Acceleration produced, $a = \dfrac{P}{m+M}$

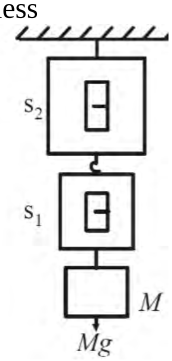
Taking the block as a system,

Force on the block, F = Ma

$\therefore$ $F = \dfrac{MP}{m+M}$

90. (1)

Sol. As springs are massless



So, tension in spring 1

= Tension in spring 2

= Mg

And, reading of spring balance is equal to tension of spring so, both will show same reading.

91. (3)

Sol. **Case-I:** For the man standing in the lift, the acceleration of the ball

$a_{bm} = a_b - a_m \Rightarrow a_{bm} = g - a$

Case-II: The man standing on the ground, the acceleration of the ball

$a_{bm} = a_b - a_m \Rightarrow a_{bm} = g - 0 = g$

92. (1)

Sol. When forces F_1, F_2 and F_3 are acting on the particle, it remains in equilibrium. Force F_2 and F_3 are perpendicular to each other,

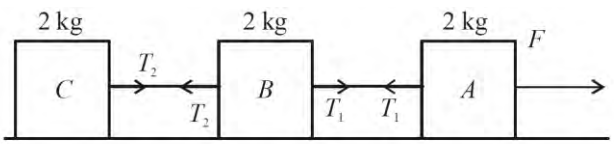
$$\therefore \; F_1 = \sqrt{F_2^2 + F_3^2}$$

The force F_1 is now removed, so, resultant of F_2 and F_3 will now make the particle move with force equal to F_1.

Then, acceleration, $a = \dfrac{F_1}{m}$

93. (2)

Sol. Force = mass × acceleration



$\therefore$ F = $(m + m + m) \times a$

F = $3m \times a$

$$\Rightarrow a = \frac{F}{3m} \Rightarrow a = \frac{10.2}{6} \text{ m/s}^2$$

$$\therefore T_2 = ma = 2 \times \frac{10.2}{6} = 3.4\text{N}$$

94. (3)

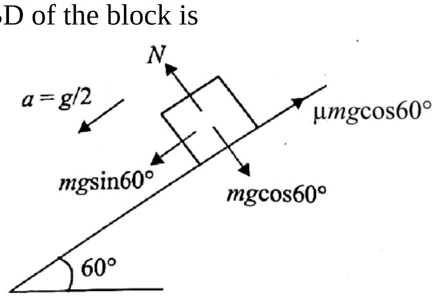
Sol. Tension, T = 360 N

$mg - T = ma$

$$\Rightarrow a = g - \frac{T}{m} = 10 - \frac{360}{60} = 4 \text{ m/s}^2$$

95. (1)

Sol. The FBD of the block is



$\therefore$ $F_{net} = ma$

$\Rightarrow mg\sin 60° - \mu mg\cos 60° = ma$

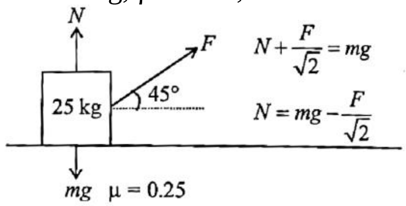
$$\Rightarrow g\sin 60° - \mu g\cos 60° = \frac{g}{2} \qquad \left[\because a = \frac{g}{2}\right]$$

$$\Rightarrow \frac{\sqrt{3}}{2} - \mu\frac{1}{2} = \frac{1}{2}$$

$$\therefore \mu = \sqrt{3} - 1$$

96. (3)

Sol. Given: m = 25 Kg, μ = 0.25, S = 5 m



Block moves with uniform velocity

$F - f = ma$

So, $a = 0 \Rightarrow F\cos 45° = f$

F = μ × N

$$\Rightarrow \frac{F}{\sqrt{2}} = \mu\left[mg - \frac{F}{\sqrt{2}}\right]$$

$$\Rightarrow \frac{F}{\sqrt{2}} = 0.25\left[25 \times 9.8 - \frac{F}{\sqrt{2}}\right]$$

$$\Rightarrow 1.25\frac{F}{\sqrt{2}} = 61.25$$

$$\Rightarrow F = \frac{61.25 \times \sqrt{2}}{1.25} = 49\sqrt{2}$$

$$W_{ext} = FS\cos 45° = 49\sqrt{2} \times 5 \times \frac{1}{\sqrt{2}} = 245 \text{ J}$$

97. (1)

Sol. Accerlation if plane is smooth,

$a = g\sin\theta$

Displacement of object

$$\ell = \frac{1}{2}(g\sin\theta)t_1^2 \qquad \therefore t_1 = \sqrt{\frac{2\ell}{g\sin\theta}}$$

Accelration of plane is rough,

$a = g\sin\theta - \mu g\cos\theta$

Displacement of object

$$\ell = \frac{1}{2}(g\sin\theta - \mu g\cos\theta)t_2^2$$

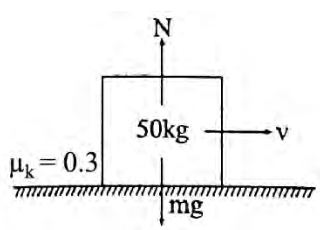
$$t_2 = \sqrt{\frac{2\ell}{g\sin\theta - \mu g\cos\theta}} = nt_1 n\sqrt{\frac{2\ell}{g\sin\theta}}$$

on comparing,

$$\mu = 1 - \frac{1}{n^2}$$

98. (2)

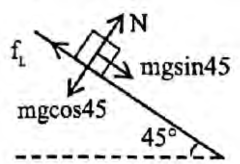
Sol.



$F_k = \mu_k N = 0.3 \times 50 \times 9.8 = 147$ N $\quad [\because N = mg]$

99. (1)

Sol. From FBD,



For brick begins to slide,

Frictional force $f_L = mg \sin 45°$

Normal reaction $N = mg \cos 45° = N$

$\therefore$ Coefficient of static friction

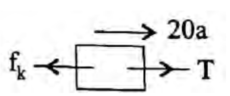
$\mu_S = \dfrac{f_L}{N} = mg \sin 45°/mg \cos 45° = \tan 45° = 1$

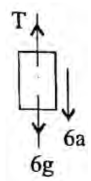
100. (3)

Sol. FBD for 6 kg block

$6a = 6g - T$ ...(i)

FBD for 20 kg block





$T - f_k = 20a$

$T - \mu(20)g = 20a$ ...(ii)

comparing (i) and (ii)

$\Rightarrow 6g - 6a = 20a + 20\mu g$

$\Rightarrow 6g - 20a \times 0.04g = 26a$

$a = \dfrac{10(6-0.8)}{26} = 2\text{m/s}^2$

101. (2)

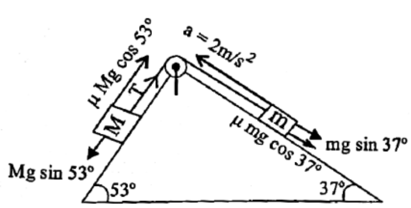
Sol. $N = mg$

For no slipping $F \le \mu N$

$\Rightarrow m\omega^2 r \le \mu mg \Rightarrow \omega^2 = \dfrac{\mu g}{r} \Rightarrow \omega = \sqrt{\dfrac{\mu g}{r}}$

102. (2)

Sol.



For M block

$Mg \sin 53° - \mu (Mg) \cos 53° - T = Ma$

$\Rightarrow T = 80 - 15 - 20 \Rightarrow T = 45$ N

For m block

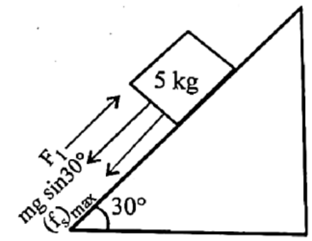
$T - mg \sin 37° - \mu mg \cos 37° = 2m$

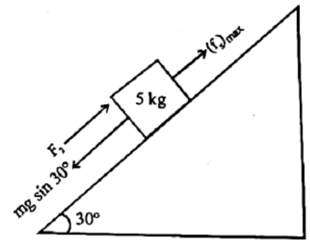
$\Rightarrow 45 = 10\,m \Rightarrow m = 4.5$ kg

103. (2)

Sol. Maximum static friction

$$(f_s)_{max} = \mu mg \cos 30° = 0.1 \times \frac{50 \times \sqrt{3}}{2} = 2.5\sqrt{3}\,\text{N}$$





$F_1 = mg \sin 30° + (f_s)_{max}$
$= (25 + 2.5\sqrt{3})$N

$F_2 = mg \sin 30° - (f_s)_{max}$
$= (25 - 2.5\sqrt{3})$N

$$\therefore F_1 - F_2 = 25 + 2.5\sqrt{3} - 25 + 2.5\sqrt{3} = 5\sqrt{3}N$$

104. (1)

Sol. Coefficient of friction, $\mu = 0.5$

$$\tan\theta = \mu = \frac{1}{2} = \frac{dy}{dx} = \frac{x}{2}$$

So $x = 1\text{m}, y = \dfrac{x^2}{4} = \dfrac{(1)^2}{4} = \dfrac{1}{4}\text{m}$

105. (2)

Sol. Co-efficient of friction (μ) is independent of the area of contact and depends on nature of surface in contact, so, it depends on material of object.

106. (4)

Sol. Initially,

Friction, $f = \mu mg = m\omega^2 R$ ...(i)

Finally,

$\mu mg = m\left(\dfrac{\omega^2}{4}\right)R'$ ...(ii)

From (i) and (ii)

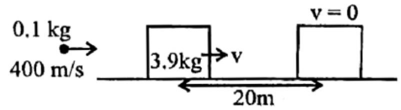
$1 = \dfrac{4R}{R'}$

$\Rightarrow R' = 4R = 4 \times 1 = 4$ cm ($\because$ R = 10 m given)

So distance from the center will be 4 cm.

107. (4)

Sol.

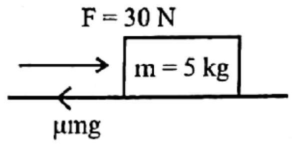


Apply the conservation of momentum

$P_i = P_f$ (Collision)

108. (1)

Sol. From equation of motion



$$S = ut + \frac{1}{2}at^2$$

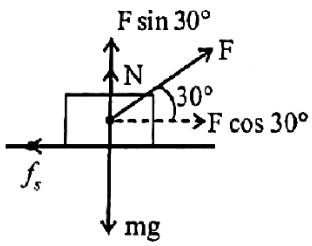
$$\Rightarrow 50 = 0 + \frac{1}{2} \times a \times 100$$

$$a = 1\ \text{m/s}^2; \text{F} - \mu\text{mg} = \text{ma}$$

$$30 - \mu \times 50 = 5 \times 1 \Rightarrow 50\mu = 25; \mu = \frac{1}{2} = 0.50$$

109. (3)

Sol. Block will just start to move when F cos 30° = f_s



$$\Rightarrow \frac{\sqrt{3}\text{F}}{2} = \mu\text{N}$$

$$\Rightarrow \frac{\sqrt{3}\text{F}}{2} = \mu(mg - \text{F}\sin 30°)$$

$$\Rightarrow \frac{\sqrt{3}\text{F}}{2} = 0.25(100 - \frac{\text{F}}{2}) \Rightarrow \frac{\sqrt{3}\text{F}}{2} = \frac{0.25}{2}(200 - \text{F})$$

$$\Rightarrow \sqrt{3}\text{F} = 50 - 0.25\text{F} \Rightarrow \text{F}(\sqrt{3} + 0.25) = 50$$

$$\Rightarrow \text{F} = \frac{50}{0.25 + \sqrt{3}} = 25.2\ \text{N}$$

110. (4)

Sol. We have

$$a = \frac{f}{m} = \frac{\mu mg}{m} = \mu g$$

$$\text{Also, } |a| = \frac{|\text{V} - u|}{t} = \frac{|20 - 0|}{5} = 4\ \text{m/s}^2$$

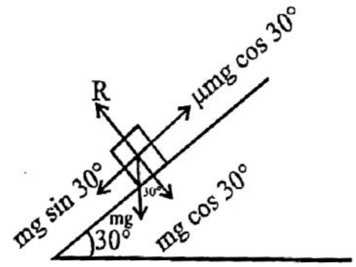
$$\text{So, } \mu g = 4 \Rightarrow \mu = \frac{4}{10} = 0.4$$

111. (2)

Sol. From the free body diagram shown.

mg sin 30° – μmg cos 300 = *ma*

$$\Rightarrow a = g\left(\frac{1}{2} - \frac{\sqrt{3}\mu}{2}\right)$$



$$\Rightarrow \frac{g}{2} - \frac{\sqrt{3}}{2}\mu g = \frac{g}{4} \Rightarrow \frac{1}{2} - \frac{\sqrt{3}\mu}{2} = \frac{1}{4}$$

$$\Rightarrow \frac{\sqrt{3}}{2}\mu = \frac{1}{4} \Rightarrow \mu = \frac{1}{2\sqrt{3}}$$

112. (4)

Sol. Let a_1 be the acceleration when it slide down smooth incline plane.

Then, $a_1 = g\sin 45° = g/\sqrt{2}$

Let a_2 be the acceleration when it slide down rough inclined plane

Then, $a_2 = g\sin 45° - \mu_k g\cos 45° = \frac{g}{\sqrt{2}} - \frac{\mu_k g}{\sqrt{2}}$

Let 't_1' be the taken when it slide down smooth surface and 't_2' be the time taken when is slide down rough surface.

$$t_2 = nt_1 \text{ and } \frac{1}{2}a_1t_1^2 = \frac{1}{2}a_2t_2^2$$

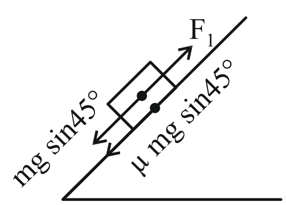
$$\Rightarrow \frac{1}{2}\frac{g}{\sqrt{2}}t_1^2 = \frac{1}{2}\left(\frac{g}{\sqrt{2}} - \frac{\mu_k g}{\sqrt{2}}\right)n^2t_1^2 \Rightarrow \mu_k = 1 - \frac{1}{n^2}$$

113. (1)

Sol. When block is just about to move up

F_1 = mg sin 45° + μmg cos 45°

$$= \frac{\text{mg}}{\sqrt{2}}(1 + \mu)$$



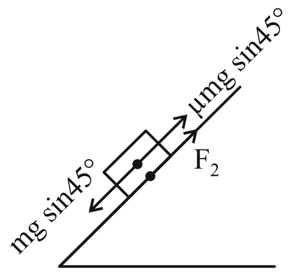
When block

When block is just about to move down

F_2 mg sin 45° – μmg cos 45°

$$= \frac{\text{mg}}{\sqrt{2}}(1 - \mu)$$

As, $F_1 - 2F_2$



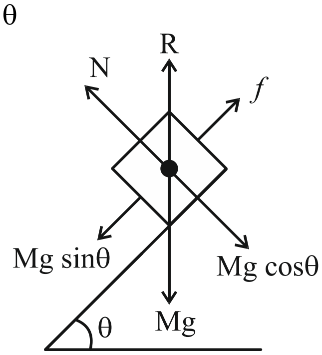
$$\Rightarrow \frac{mg}{\sqrt{2}}(1+\mu) = 2\frac{mg}{\sqrt{2}}(1-\mu)$$
$$\Rightarrow 1+\mu = 2(1-\mu) \Rightarrow 1+\mu = 2-2\mu$$
$$\Rightarrow 3\mu = 1 \Rightarrow \mu = \frac{1}{3} = 0.33$$

114. (2)

Sol. Retardation due to friction $n = \frac{\mu M g}{M} = \mu g \Rightarrow a = -\mu g$

Now, $s = \frac{v^2 - u^2}{2a} = \frac{0^2 - 2^2}{-2\mu g} = \frac{2}{0.4 \times 10} = 0.5\text{m}$

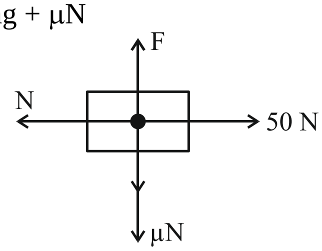
115. (1)
Sol. From the free diagram shown
N = Mg cos θ
f = Mg sin θ



Contact force, $R = \sqrt{N^2 + f^2}$

$$\Rightarrow R = \sqrt{(Mg\cos\theta)^2 + (Mg\sin\theta)^2}$$
$$= \sqrt{(Mg)^2(\cos^2\theta + \sin^2\theta)} \Rightarrow R = Mg$$

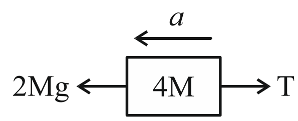
116. (4)
Sol. By FBD of block, we have
N = 50 N
And F ≤ mg + μN



i.e. ≤ 2g + 0.5 × 50
≤ 20 + 25 ≤ 45 N
So, Maximum force that can be applied is 45N.

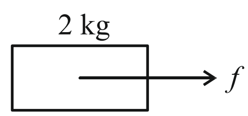
117. (4)
Sol. For 4 kg block
$4g - T = 4a$ ….(i)
For 40 kg block
$T - 40g \times 0.02 = 40a$ [∵ $f_k = \mu$ mg]
$T - 8 = 40a$ ….(ii)
Adding (i) and (ii),we get
$40 - 8 = 44a$
$a = \frac{32}{44} = \frac{8}{11}$ m/s²

118. (6)
Sol. For 4M
2Mg – T = 4 Ma …(i)
For M

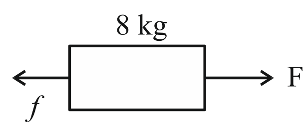


T – Mg = Ma …(ii)
Adding (i) and (ii), we get
$$Mg = 5Ma \Rightarrow a = \frac{g}{5}$$
$$\text{So, } T = Ma + Mg = \frac{Mg}{5} + Mg = \frac{6}{5}Mg$$

119. (3)
Sol.



$f = 2a$ ...(i)



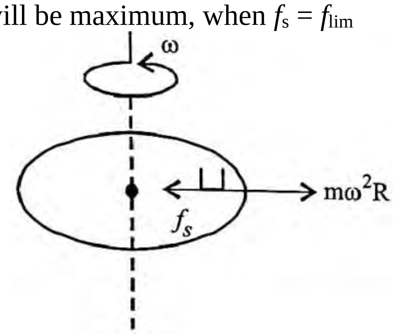
$F = f = 8a$ ...(ii)

Clearly, from (i) 'a' will be maximum when $f = f_{lim}$

So, $a_{max} = \frac{f_{lim}}{2} = \frac{\mu \times 2g}{2} = \mu g$

From (ii), $F_{max} = 8a_{max} + f_{lim} = 8\mu g + 2\mu g = 10\mu g = 49N$

120. (2)
Sol. For beaker to move with disc
$f_s = m\omega^2 R$
So, R will be maximum, when $f_s = f_{lim}$



Therefore,

$f_{lim} = m\omega^2 R_{max}$

$\mu mg = m\omega^2 R_{max}$

$R_{max} = \dfrac{\mu g}{\omega^2}$

So, $R \le \dfrac{\mu g}{\omega^2}$

121. (2)

Sol. $a = \dfrac{f}{m} = \dfrac{\mu mg}{m} = \mu g$

So, $S = \dfrac{u^2}{2a}$ $\quad [\because v = 0]$

$S = \dfrac{(9.8)^2}{2\times\mu g} = \dfrac{(9.8)^2}{2\times 0.5\times 9.8} = 9.8\text{ m}$

122. (3)

Sol. Acceleration on smooth inclined plane

$a = g \sin 30° = g/2$

Using $S = ut + \dfrac{1}{2}at^2$

$\Rightarrow S = \dfrac{1}{2}gT^2 = \dfrac{g}{4}T^2$ $\quad$ …(i) $\quad (\because u = 0)$

Acceleration on rough inclined plane

$a = g\sin 30° - \mu g\cos 30° = \dfrac{g}{2} - \dfrac{\mu g\sqrt{3}}{2}$

$\Rightarrow a = \dfrac{g}{2}(1-\mu\sqrt{3})$

Using again $S = ut + \dfrac{1}{2}at^2$

$\Rightarrow S = \dfrac{1}{4}g(1-\sqrt{3}\mu)(\alpha T)^2$ $\quad$ …(ii)

By (i) and (ii)

$= \dfrac{1}{4}gT^2 = \dfrac{1}{4}g(1-\sqrt{3}\mu)\alpha^2T^2 \Rightarrow 1-\sqrt{3}\mu = \dfrac{1}{\alpha^2}$

$\Rightarrow \mu = \left(\dfrac{\alpha^2-1}{\alpha^2}\right)\dfrac{1}{\sqrt{3}} \Rightarrow x = 3.00$

123. (15)

Sol. For block of mass 1 kg

$F = f_{s,max}$

$\Rightarrow 1\text{ kg} \times a = \mu N = \mu \times 1 \times g$ $\quad (\because N = mg)$

$\Rightarrow a = 0.5 \times 1 \times 10 = 5\text{ m/s}^2$

$\therefore$ Maximum horizontal force,

$F_{max} = ma = (1 + 2) \times 5 = 15\text{ N}$

124. (3)

Sol. From question,

$t_a = \dfrac{1}{2}t_d$

$\sqrt{\dfrac{2s}{a_a}} = \dfrac{1}{2}\sqrt{\dfrac{2s}{a_d}}$

Or, $a_a = 4a_d$ $\quad$ …(i)

$g\sin\theta + \mu g\cos\theta = 4(g\sin\theta - \mu g\cos\theta)$

$\Rightarrow 5\mu g\cos\theta = 3g\sin\theta \Rightarrow \mu = \dfrac{3\tan\theta}{5}$

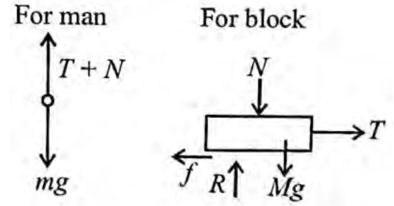
$\Rightarrow \mu = \dfrac{\sqrt{3}}{5}$ $\quad [\because \theta = 30°]$

So, $x = 3$

125. (30)

Sol. From FBD shown, $T = mg - N$

$R = Mg + N = (M + m)g - T$



For no movement of block,

$T \le \mu R \Rightarrow T \le \mu[(M+m)g - T]$

$\Rightarrow T \le \dfrac{\mu(M+m)g}{1+\mu} \Rightarrow T \le \dfrac{(0.5)(5+4)\times 10}{1+0.5}$

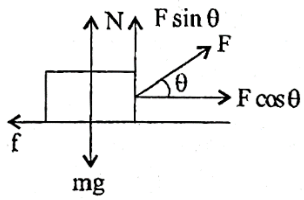
$\Rightarrow T \le 30\text{ N}$

$\therefore T_{max} = 30\text{ N}$

126. (5)

Sol. As block is at rest

So, $F\cos\theta = f = \mu N$



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

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

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

For F_{min}

$(\cos\theta + \mu\sin\theta) = 0 \Rightarrow \tan\theta = \mu$

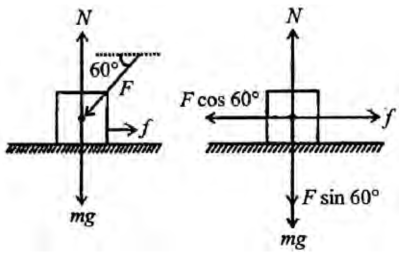
i.e. $\dfrac{d}{d\theta}(\cos\theta + \mu\sin\theta) = 0 \Rightarrow \tan\theta = \mu$

So, $\sin\theta = \dfrac{\mu}{\sqrt{1+\mu^2}}$ and $\cos\theta = \dfrac{1}{\sqrt{1+\mu^2}}$

Thus, $F_{min} = \dfrac{\mu mg}{\dfrac{1}{\sqrt{1+\mu^2}} + \dfrac{\mu\cdot\mu}{\sqrt{1+\mu^2}}} = \dfrac{\mu mg}{\sqrt{1+\mu^2}}$

127. (3.33)

Sol.



From the condition of equilibrium

N = mg + F sin 60°

For no movement of the block

F cos 60° ≤ f

⇒ F cos 60° ≤ μ (mg + F sin 60°)   (∵ f = μN)

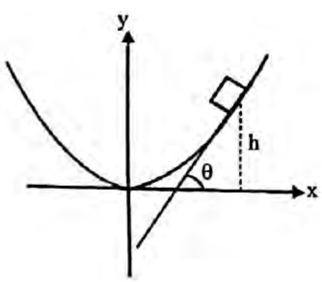
$\Rightarrow\ F \le \dfrac{\mu mg}{\cos 60^\circ - \mu \sin 60^\circ} \Rightarrow F_{critical} = 10\text{ N}$

As $F_{critical} = 3x$

So, $3x = 10 \Rightarrow x = 3.33$

128. (25)

Sol.



Block will fall down when θ = angle of repose i.e.,

tan θ = μ

$\therefore\ \tan\theta = \dfrac{dy}{dx} = \dfrac{d}{dx}\left(\dfrac{x^2}{4}\right) = \dfrac{x}{2}$ and at time of maximum height tan θ = μ = 0.5

$\Rightarrow x = 1$ and therefore $y = \dfrac{x^2}{4} = \dfrac{(1)^2}{4} = 0.25\text{ m} = 25\text{ cm}$

129. (25)

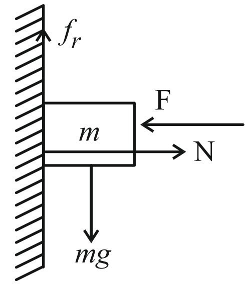
Sol. F.B.D. of the block is shown in the diagram

Since, block is at rest,

$\therefore f_r - mg = 0$ …(i)

F – N = 0   …(ii)

Also, $f_r \le \mu$N



In limiting case,

$f_r = \mu N = \mu F$ …(iii)

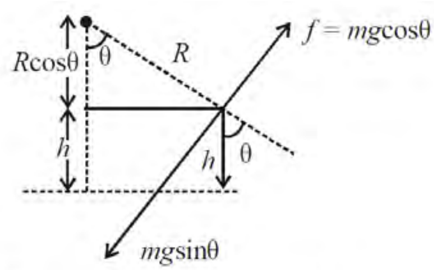
Using equation (i) and (iii),

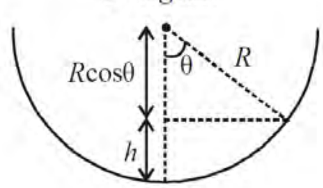
$F = \dfrac{mg}{\mu} \Rightarrow F = \dfrac{0.5\times 10}{0.2} = 25\text{N}$

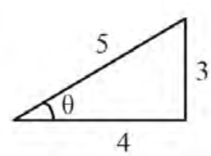
130. (1)

Sol. For balancing, mg sinθ = f = μmg cosθ

$\Rightarrow\ \tan\theta = \mu = \dfrac{3}{4} = 0.75$







$h = R - R\cos\theta = R - R\left(\dfrac{4}{5}\right) = \dfrac{R}{5}$

$\therefore\ h = \dfrac{R}{5} = 0.2\text{m}$ [∵ radius, R = 1m]

131. (346)

Sol. $Sv = Sd$

$\dfrac{v_0^2}{2a_u} = \dfrac{v_0^2/4}{2a_d} \Rightarrow a_u = 4a_d$

$\Rightarrow\ g\sin\theta + \mu g\cos\theta = 4(g\sin\theta - \mu g\cos\theta)$

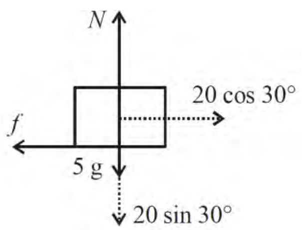
$\Rightarrow\ \mu = \dfrac{3}{5}\tan\theta \Rightarrow \mu = \dfrac{3}{5}\cdot\dfrac{1}{\sqrt{3}} = \dfrac{\sqrt{3}}{5} = 0.346 = \dfrac{346}{1000}$

So, I = 346

132. (3)

Sol. A : N = 5g + 20 sin 30°

$= 50 + 20\times\dfrac{1}{2} = 60\text{N}$

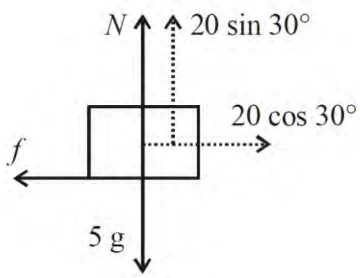


Accelaration, $a_1 = \dfrac{F - f}{m}$

$= \dfrac{20\cos 30° - \mu N}{5}$

$= \dfrac{\left[20 \times \dfrac{\sqrt{3}}{2} - 0.2 \times 60\right]}{5}$

$= 1.06 \text{ m/s}^2$



B : N = 5g – 20 sin 30°

$= 50 - 20 \times \dfrac{1}{2} = 40 \text{ N}$

$a_2 = \dfrac{F - f}{m} = \dfrac{20\cos 30° - 0.2 \times 40}{5} = 1.86 \text{ m/s}^2$

Now $a_2 - a_1 = 1.86 - 1.06 = 0.8 \text{ m/s}^2$

133. (2)

Sol. Taking (A + B) as system

$F - \mu(M + m)g = (M + m)a$

$\Rightarrow a = \dfrac{F - \mu(M + m)g}{(M + m)}$

$\Rightarrow a = \dfrac{F - (0.2)4 \times 10}{4} = \left(\dfrac{F - 8}{4}\right)$

But, $a_{max} = \mu g = 0.2 \times 10 = 2$

$\therefore \dfrac{F - 8}{4} = 2 \Rightarrow F = 16N$

134. (1)

Sol. From figure, 2 + mg sin 30° = μmg cos30° and 10 = mg sin 30° + μmg cos 30° = 2μmg cos 30° – 2

$\Rightarrow$ 6 = μmg cos 30° and 4 = mg sin 30°

By dividing above two $\Rightarrow \dfrac{3}{2} = \mu \times \sqrt{3}$

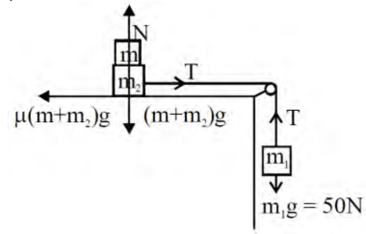
$\therefore$ Coefficient of friction, $\mu = \dfrac{\sqrt{3}}{2}$

135. (2)

Sol. Given: m_1 = 5kg; m_2 = 10kg; μ = 0.15

FBD for m_1, $m_1g - T = m_1a$

$= (10 + m)a$



For rest $a = 0$

or, $50 = 0.15(m + 10)10$

$\Rightarrow 5 = \dfrac{3}{20}(m + 10)$

$\dfrac{100}{3} = m + 10$

$\therefore m = 23.3$ kg; close to option (2)

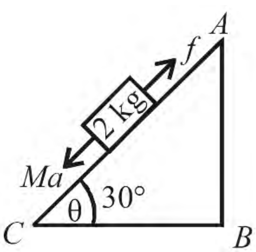
136. (4)

Sol. Equation of motion when the mass slides down

Mg sin θ - f = Ma

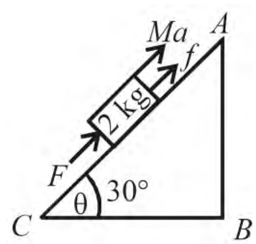
$\Rightarrow$ 10 – f = 6 (M = 2 kg, a = 3 m/s^2, θ = 30° given)

$\therefore$ f = 4N



Equation of motion when the block is pushed up

Let the external force required to take the block up the plane with same acceleration be F



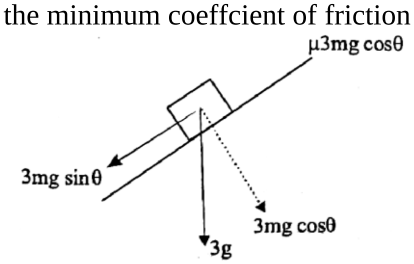
F – Mg sin θ – f = Ma

$\Rightarrow$ F – 10 – 4 = 6

F = 20 N

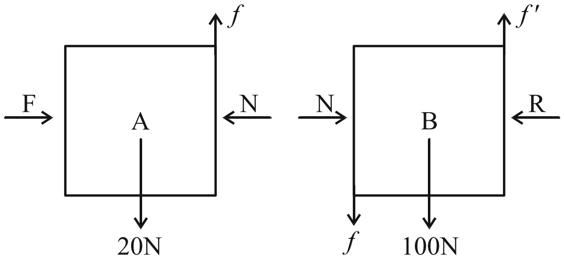
137. (2)

Sol. Let be the minimum coeffcient of friction



At equilibrium, mass does not move so,
3 mg sin θ = μ3 mg cos θ
$\therefore$ μ_{min} = tanθ

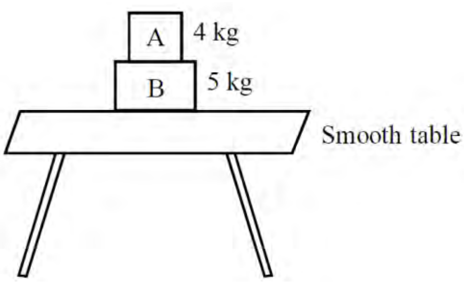
138. (1)
Sol.



Along vertical direction
A → f = 20 N
B → f' = f + 100 = 20 + 100 = 120 N

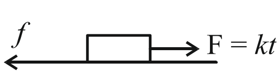
139. (2)
Sol. Initial speed at point A, $u = v_0$
Speed at point B, v = ?
$v^2 - u^2 = 2gh$
$v^2 = v_0^2 + 2gh$
Let ball travels distance 'S' before coming to rest
$$S = \frac{v^2}{2\mu g} = \frac{v_0^2 + 2gh}{2\mu g} = \frac{v_0^2}{2\mu g} + \frac{2gh}{2\mu g} = \frac{h}{\mu} + \frac{v_0^2}{2\mu g}$$

140. (3)
Sol. Minimum force on A
= frictional force between the surfaces = 12 N

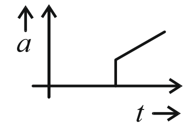


Therefore maximum acceleration
$$a_{max} = \frac{12\text{N}}{4\text{kg}} = 3\text{m/s}^2$$
Hence maximum force,
F_{max} = total mass × a_{max}
= 9 × 3 = 27 N

141. (2)
Sol.



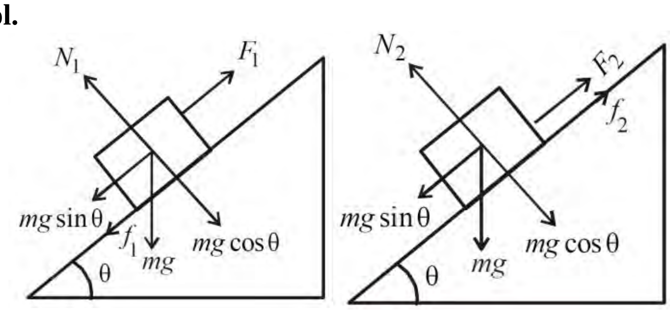
$$a = \frac{kt - \mu mg}{m}$$
$$a = \frac{kt}{m} - \mu g$$



So, a-t graph will be as shown

142. (4)
Sol. $a = g$ sin 45° – μg cos 45°
$a = g$ sin 45° – 0.3 xg cos 45°
$$= \frac{g}{\sqrt{2}} - \frac{0.3gx}{\sqrt{2}} = 5\sqrt{2} - 0.3(5\sqrt{2})x = 5\sqrt{2} - 1.5\sqrt{2}x$$
Velocity will increase until a = 0 and when $v = v_{max}$, then a = 0
$$0 = 5\sqrt{2} - 1.5\sqrt{2}x$$
$$x = \frac{5\sqrt{2}}{1.5\sqrt{2}}$$
x = 3.33 m

143. (3)
Sol.



or, F_1 = mg sin θ + μmg cosθ
When the body slides the inclined plane, then
mg sin θ–f_2 = F_2
or F_2 = mg sin θ – μmg cos θ
$$\therefore \frac{F_1}{F_2} = \frac{\sin\theta + \mu\cos\theta}{\sin\theta - \mu\cos\theta}$$
$$\Rightarrow \frac{F_1}{F_2} = \frac{\tan\theta + \mu}{\tan\theta - \mu} = \frac{2\mu + \mu}{2\mu - \mu} = \frac{3\mu}{\mu} = 3$$

144. (4)
Sol. For first half acceleration = g sin ϕ;
For second half
acceleration = – (g sin ϕ – μg cos ϕ)
For the block to come to rest at the bottom, acceleration in I half-retardation in II half.
g sin ϕ = – (g sin ϕ – μg cos ϕ) ⇒ μ = 2 tan ϕ
NOTE:
According to work-energy theorem, W = ΔK = 0
(Since initial and final speeds are zero)
$\therefore$ Workdone by friction + Work done by gravity = 0
i.e., $-(\mu mg\cos\phi)\frac{\ell}{2} + mg\ell\sin\phi = 0$
or $\frac{\mu}{2}\cos\phi = \sin\phi$ or μ = 2tanϕ

145. (1)

Sol. Given, initial velocity, u = 100 m/s.

Final velocity, v = 0

Acceleration, $a = \mu_k g = 0.5 \times 10$

$v^2 - u^2 = 2as$ or

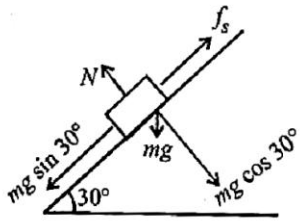
$\Rightarrow 0^2 - \mu^2 = 2(-\mu_k g)s$

$\Rightarrow s = 100$ m

146. (3)

Sol. Since the body is at rest on the inclined plane,

$mg \sin 30°$ = Force of friction



$\Rightarrow m \times 10 \times \sin 30° = 10$

$\Rightarrow m \times 5 = 10 \Rightarrow m = 2$kg

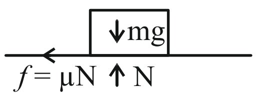
147. (4)

Sol. u = 6 m/s, v = 0, t = 10s, a = ?

Acceleration $a = \dfrac{v-u}{t}$

$\Rightarrow a = \dfrac{0-6}{10}$

$\Rightarrow a = \dfrac{-6}{10} = -0.6\text{m/s}^2$



The retardation force is due to the frictional force

$\therefore f = -ma$

$\Rightarrow \mu N = -ma$

$\Rightarrow \mu mg = -ma$

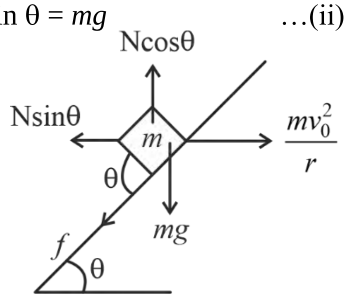
$\Rightarrow \mu = -\dfrac{ma}{mg}$

$\Rightarrow \mu = -\dfrac{-a}{g} = \dfrac{0.6}{10} = 0.06$

148. (3)

Sol. $N\sin\theta + f\cos\theta = \dfrac{mv_0^2}{r}$ …(i)

$N\cos\theta - f\sin\theta = mg$ …(ii)



From eq. (i) and (ii),

$$\frac{\sin\theta + \mu\cos\theta}{\cos\theta - \mu\sin\theta} = \frac{v_0^2}{rg}; rg\tan\theta + \mu rg = v_0^2 - v_0^2\mu\tan\theta$$

$$\mu = \frac{v_0^2 - rg\tan\theta}{rg + v_0^2\tan\theta}$$

149. (2)

Sol. Centripetal accerlation is,

$a_c = \omega^2 x$

$\dfrac{vdv}{dx} = \omega^2 x$ $\left[\because a_c = v\dfrac{dv}{dx}\right]$

On intigration by applying limits,

$$\int_0^v vdv = \int_1^3 \omega^2 x dx$$

$$\left[\frac{v^2}{2}\right]_0^v = \omega^2\left[\frac{x^2}{2}\right]_1^3$$

$$\frac{v^2}{2} = \frac{\omega^2}{2}[3^2 - 1^2] \Rightarrow v = 2\sqrt{2}\omega$$

$\therefore x = 2$

150. (2)

Sol. Maximum velocity is given by:

$$V = \sqrt{Rg\left[\frac{\tan\theta + \mu}{1 - \mu\tan\theta}\right]} = \sqrt{300 \times g \times \left[\frac{\tan 30° + 0.2}{1 - 0.2 \times \tan 30°}\right]}$$

$$= \sqrt{300 \times 10 \times \left[\frac{0.57 + 0.2}{1 - 0.2 \times 0.57}\right]} = 51.4 \text{ m/s}$$

151. (2)

Sol. Given: R = 9m,

$$N = \frac{120}{3} \text{ rpm} = 40 \text{ rpm}$$

$$\omega = \frac{2\pi N}{60} = \frac{2\pi \times 40}{60} = \frac{4\pi}{3} \text{ rad/s}$$

$$a_{\text{centripetal}} = \omega^2 R = \left(\frac{4\pi}{3}\right)^2 \times 9 = 16\pi^2 \text{ m/s}^2$$

152. (2)

Sol. Maximum Tension, T = $m\omega^2\ell$

$$\omega = \sqrt{\frac{T}{m\ell}} = \sqrt{\frac{400}{0.5 \times 0.5}} = 40\text{rad/s}$$

153. (3)

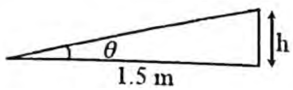
Sol. Centripetal force, $F = \dfrac{mv^2}{r} \Rightarrow v^2 \propto r$

(For same m and F)

$\Rightarrow \dfrac{v_1}{v_2} = \sqrt{\dfrac{r_1}{r_2}} = \dfrac{\sqrt{3}}{2}$ $[\because r_1 : r_2 = 3:4]$

154. (2)

Sol. To negotiate curve, $\tan\theta = \dfrac{v^2}{Rg} = \dfrac{12\times12}{10\times400}$



$\tan\theta = \dfrac{h}{1.5} \Rightarrow \dfrac{h}{1.5} = \dfrac{144}{4000}$

Therefore, outer rail raised with height, h = 5.4 cm

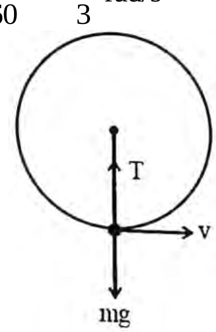
155. (4)

Sol. Given that

$m = 900\text{ g} = \dfrac{900}{1000}\text{ kg} = \dfrac{9}{10}\text{ kg}$

r = 1 m, N = 10 rpm

$\omega = \dfrac{2\pi N}{60} = \dfrac{2\pi(10)}{60} = \dfrac{\pi}{3}\text{ rad/s}$



For circular motion, at lowest point

$F_{net} = mr\omega^2$

$\Rightarrow T - mg = mr\omega^2$

$\Rightarrow T = mg + mr\omega^2$

$\dfrac{9}{10}\times9.8 + \dfrac{9}{10}\times1\left(\dfrac{\pi}{3}\right)^2 = 8.82 + 0.98 = 9.80\text{N}$

156. (1)

Sol. Centripetal force $F_c = \dfrac{mv^2}{r}$ and $v = r\times\omega$

$\therefore$ Fc = $m\omega^2 r = 200\times(0.2)^2\times70 = 560$ N

157. (4)

Sol. Given, mass of child, m = 5kg

Radius of merry-go-round, R = 2m

Angular velocity, $\omega = \dfrac{2\pi}{3.14} = 2\text{ rad/s}$

The centrifugal force on the child will be

$F = m\omega^2 R = 5\times2^2\times2 = 40\text{N}$

158. (3)

Sol. Centripetal force, $f_c = \dfrac{mv^2}{r}$

Frictional force = μmg

Here, centripetal force for motion is being provided by the friction.

$\therefore \dfrac{mV^2}{r} = \mu mg$

$V_{max} = \sqrt{\mu rg} = \sqrt{0.34\times50\times10} \approx 13\text{m/s}$

159. (40)

Sol. $v\dfrac{dv}{dx} = a \Rightarrow v\dfrac{dv}{dx} = \dfrac{v^2}{R} \Rightarrow \int_{15}^{v}\dfrac{dv}{v} = \dfrac{1}{R}\int_0^x dx$

$\Rightarrow \ln\dfrac{v}{15} = \dfrac{x}{R} \Rightarrow e^{x/R} = \dfrac{v}{15} \Rightarrow v = 15e^{x/R}$

$\Rightarrow \dfrac{dx}{dt} = 15e^{x/R} \Rightarrow \int_0^{\frac{\pi R}{2}} e^{-x/R}dx = 15\int_0^{t_0} dt$

$\Rightarrow t_0 = 40(1 - e^{-\pi/2})$

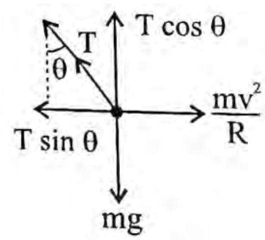
160. (3)

Sol. Given that speed, v = 20 m/s

Radius of circular track, R = 40 m

T cos θ = mg …(i)

T sin θ = $\dfrac{mv^2}{R}$ ...(ii)



Divide equation (ii) by (i), we have

$\tan\theta = \dfrac{v^2}{Rg}$

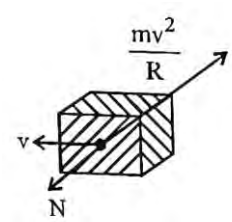
$\tan\theta = \dfrac{20^2}{40\times10}$

$\tan\theta = 1 \Rightarrow \theta = \dfrac{\pi}{4}$

161. (1)

Sol. For observer on block,

$N = \dfrac{mv^2}{r} \Rightarrow N \propto v^2$



So, curve is parabola,

symmetric about N – axis

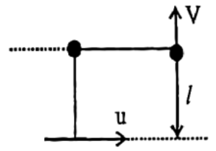
162. (2)

Sol. $\Delta V = |\vec{V} - \vec{u}| = \sqrt{V^2 + u^2}$ $\quad \left[\because \vec{V} \perp \vec{u}\right]$

Now, $K_1 + P_1 = K_2 + P_2$

$\Rightarrow \frac{1}{2}mu^2 + 0 = \frac{1}{2}mV^2 + mgl \Rightarrow V^2 = u^2 - 2gl$

$\Rightarrow V = \sqrt{u^2 - 2gl}$



So, $\Delta V = \sqrt{V^2 + u^2} = \sqrt{u^2 - 2gl + u^2}$

$= \sqrt{2(u^2 - gl)} \Rightarrow x = 2$

163. (3)

Sol. By law of conservation of mechanical energy,

$K_P + P_P = K_Q + P_Q$

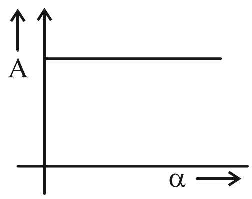
$\Rightarrow 0 + mgR\sin\alpha = \frac{1}{2}mv^2 \Rightarrow v^2 = 2Rg\sin\alpha$

At point 'Q', $N = \frac{mv^2}{R} + mg\sin\alpha$

$$\Rightarrow \frac{N}{\left(\frac{mv^2}{R}\right)} = 1 + \frac{Rg}{v^2}\sin\alpha = 1 + \frac{Rg\sin\alpha}{2Rg\sin\alpha} = \frac{3}{2}$$

$\Rightarrow$ A = constant

So, graph between A and a will be as shown below.



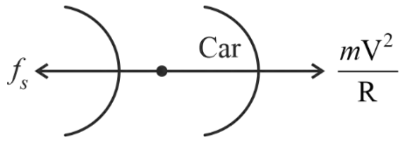
164. (24)

Sol. $f_{s,}\max = \frac{mV_{max}^2}{R}$

$\Rightarrow \mu mg = \frac{mV_{max}^2}{R}$

$\Rightarrow V_{max} = \sqrt{\mu Rg}$

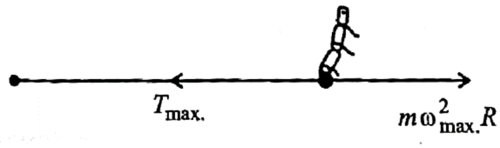
So, $\frac{V_{2,max}}{V_{1,max}} = \sqrt{\frac{R_2}{R_1}}$



$$\Rightarrow V_{2,max} = V_{1,max} \times \sqrt{\frac{R_2}{R_1}} = 30 \times \sqrt{\frac{48}{75}} = 30 \times \frac{4}{5} = 24 \text{ m/s.}$$

165. (3)

Sol.



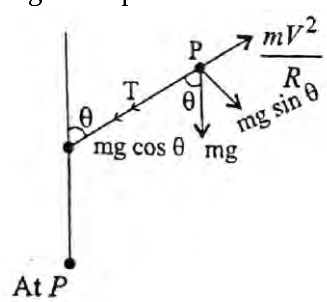
$T_{max} = m\omega^2_{max}R$

$80 = 0.1 \times \left(\frac{k}{30}\right)^2 \times 2 \quad \left[\because \omega = \frac{k}{\pi} \times \frac{2\pi}{60} = \frac{k}{30}\right]$

$\Rightarrow k^2 = \frac{30^2 \times 80}{2 \times 0.1} \Rightarrow k^2 = 360000 \Rightarrow k = 600$

166. (2)

Sol. Let us take a general point 'P'



$T + mg\cos\theta = \frac{mv^2}{R} \Rightarrow T = \frac{mv^2}{R} - mg\cos\theta$

So, T will be minimum when, mg cos θ is maximum

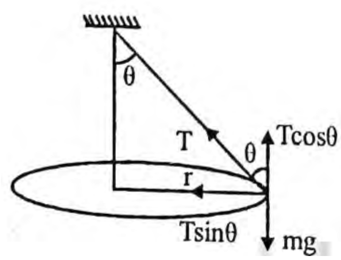
i.e., when cos θ is maximum

i.e. when θ = 0

and θ is zero when string is at highest point.

167. (1)

Sol. From figure



$\sin\theta = \frac{r}{L} = \frac{L}{L\sqrt{2}} = \frac{1}{\sqrt{2}} \Rightarrow \theta = 45^\circ$

$T\sin\theta = \frac{mv^2}{r}$ $\quad \ldots(i)$

$T\cos\theta = mg$ $\quad \ldots(ii)$

$\tan\theta = \frac{v^2}{rg} \Rightarrow v = \sqrt{rg}$

168. (2)

Sol. Given, mass of the block, m = 200g = 200 × 10^{-3} Kg

Radius of the circular groove r = 20

Time taken to complete one round, T= 40 s

Here, normal force will provide the necessary centripetal force.

$$N = m\omega^2 r = 200\times10^{-3}\times\left(\frac{2\pi}{40}\right)^2\times0.2 = 9.859\times10^{-4}\,N.$$

169. (3)

Sol. For statement-I

The maximum speed by which cyclist can take a turn on a circular path.

$$\Rightarrow v \le \sqrt{\mu r g} \le \sqrt{0.2\times2\times9.8}$$

$$\Rightarrow v \le \sqrt{3.92} \Rightarrow v_{max} = 1.97\text{m/s}$$

Speed of cyclist, $v = 7\text{ kmh}^{-1} = 7\times\frac{5}{18} = 1.94$ m/s

As, $v < v_{max} \Rightarrow$ cyclist will not slip

The maximum safe speed on a banked frictional road

$$v_{allowable} = \sqrt{rg\frac{(\mu+\tan\theta)}{1-\mu\tan\theta}}$$

$$\Rightarrow v = \sqrt{\frac{2\times9.8(0.2+\tan45°)}{1-0.2\times\tan45°}}$$

$$= \sqrt{\frac{2\times9.8\times1.2}{0.8}} = 5.42\text{ m/s}$$

As, $v < v_{allowable} \Rightarrow$ cyclist cross the curve without slipping

So, both the statements are true.

170. (5)

Sol. At the highest position,

$$T_{min} = \frac{mv_{min}^2}{l} - mg$$

At the lowest position,

$$T_{max} = \frac{mv^2}{l} + mg \qquad \text{(Given)}$$

And we know,

$$T_{max} - T_{min} = 6mg \Rightarrow 5T_{min} - T_{min} = 6mg$$

$$\therefore\ T_{min} = \frac{3}{2}mg = \frac{mv_{min}^2}{l} - mg$$

$$\therefore v_{min} = \sqrt{\frac{5}{2}gl} = \sqrt{\frac{5}{2}\times10\times1} = 5\text{ m/s}.$$

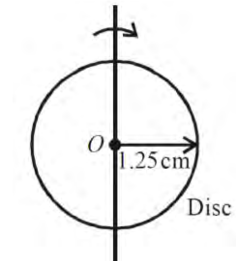
171. (4)

Sol. Using, $\mu mg = \frac{mv^2}{r} = mr\omega^2$

$\omega = 2\pi n = 2\pi \times 3.5\ 7\ \pi$ rad/sec

Radius, r = 1.25 cm = 1.25 × 10^{-2} m

Coefficient of friction, μ = ?



$$\Rightarrow \mu = \frac{r\omega^2}{g} = \frac{1.25\times10^{-2}\times\left(7\times\frac{22}{7}\right)^2}{10}$$

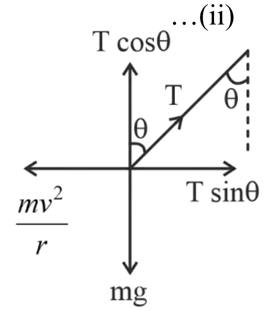
$$= \frac{1.25\times10^{-2}\times22^2}{10} = 0.6$$

172. (4)

Sol. Given, θ = 45°, r = 0.4 m, g = 10 m/s^2

$T\sin\theta = \frac{mv^2}{r}$ …(i)

$T\cos\theta = mg$ …(ii)



From equation (i) & (ii) we have,

$$\tan\theta = \frac{v^2}{rg}$$

$v_2 = rg \qquad \because \theta = 45°$

Hence, speed of the pendulum in its circular path,

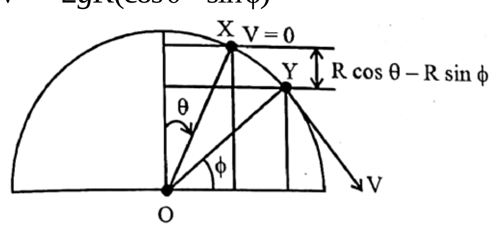
$v\sqrt{rg} = \sqrt{0.4\times10} = 2\text{m/s}$

173. (3)

Sol. $K.E_X + P.E_X = K.E_Y + P.E_Y$

$$\Rightarrow mgR(\cos\theta - \sin\phi) = \frac{1}{2}mV^2$$

$$\Rightarrow V^2 = 2gR(\cos\theta - \sin\phi)$$



at Y, $\frac{mV^2}{R} = mg\sin\phi \qquad [\because N_Y = 0]$

$$\Rightarrow 2mg(\cos\theta - \sin\phi) = mg\sin\phi$$

$$\Rightarrow \sin\phi = \frac{2}{3}\cos\theta$$

174. (1)

Sol. Initially, $k \times 1 = m\omega^2 R$ …(i)

Finally, $k \times 5 = m(2\omega)^2 (R + 5)$ …(ii)

From (i) and (ii), we get: R = 15 cm

So, original length, R = 15 cm.

175. (4)

Sol. $s = t^3 + 5$

$\Rightarrow$ velocity, $v = \frac{ds}{dt} = 3t^2$

Tangential acceleration, $a_t = \frac{dv}{dt} = 6t$

Radial acceleration, $a_c = \frac{v^2}{R} = \frac{9t^4}{R}$

At, $t = 2$s, $a_t = 6 \times 2 = 12$ m/s^2

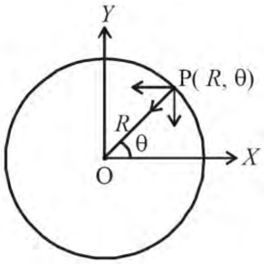
$a_c = \frac{9 \times 16}{20} = 7.2$ m/s^2

$\therefore$ Resultant acceleration $= \sqrt{a_t^2 + a_c^2}$

$= \sqrt{(12)^2 + (7.2)^2} = \sqrt{144 + 51.84} = \sqrt{195.84} = 14$ m/s^2

176. (3)

Sol. $\vec{a} = a_c \cos\theta(-\hat{i}) + a_c \sin\theta(-\hat{j})$



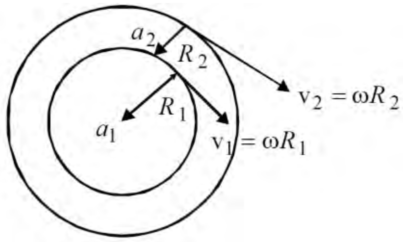
$= \frac{-v^2}{R}\cos\theta\hat{i} - \frac{v^2}{R}\sin\theta\hat{j}$

177. (3)

Sol. Let m is the mass of each particle and ω is the angular speed of the annular ring.

$a_1 = \frac{v_1^2}{R_1} = \frac{\omega^2 R_1^2}{R_1} = \omega^2 R_1$

$a_2 = \frac{v_2^2}{R_2} = \omega^2 R_2$



$\frac{F_1}{F_2} = \frac{ma_1}{ma_2} = \frac{mR_1\omega^2}{mR_2\omega^2} = \frac{R_1}{R_2}$

Note:

The force experienced by any particle is only along radial direction.

Force experienced by the particle, $F = m\omega^2 R$

$\therefore \frac{F_1}{F_2} = \frac{R_1}{R_2}$

178. (2)

Sol. Only option (2) is filse since accelaation vector is always radial (i.e. towards the center) for uniform circular motion.