Chapter 5

Laws of Motion

Solutions

SECTION - A

Objective Type Questions

(The Law of Inertia Newton's First Law of Motion)

1. An athlete does not come to rest immediately after crossing the winning line due to the

   (1) Inertia of rest (2) Inertia of motion (3) Inertia of direction (4) None of these

Sol. Answer (2)

While running athlete is in the state of motion. So due to inertia of motion athlete does not come to rest.

2. Newton's first law is applicable

   (1) In all reference frames (2) Only in inertial reference frames

   (3) Only in non-inertial reference frames (4) None of these

Sol. Answer (2)

Newton's law is applicable only in inertial reference frames.

3. When an object is in equilibrium state, then

   (1) It must be at rest (2) No force is acting on it

   (3) Its net acceleration must be zero (4) All of these

Sol. Answer (3)

Equilibrium $\Rightarrow \vec{F}_{net} = 0$

Using Newton's second law, $\vec{a} = 0$

4. A body of mass 2 kg is sliding with a constant velocity of 4 m/s on a frictionless horizontal table. The force required to keep the body moving with the same velocity is

   (1) 8 N (2) 0 N (3) 2×10^4 N (4) $\frac{1}{2}$ N

Sol. Answer (2)

For constant velocity, no force is required so $\vec{F} = 0$

(Newton's Second Law of Motion)

5. From Newton’s second law of motion, it can be inferred that
   (1) No force is required to move a body uniformly along straight line
   (2) Accelerated motion is always due to an external force
   (3) Inertial mass of a body is equal to force required per unit acceleration in the body
   (4) All of these

Sol. Answer (4)

By Newton's second law

$\vec{F} = m\vec{a}$ …(i)

for (i) Uniform motion means body is moving with constant velocity. By (i) it can be said that only for accelerated motion force is required (2) is true using (i)

(3) Using (i) $\vec{a} = \dfrac{\vec{F}}{m}$ so this is true

6. If a force of constant magnitude acts in direction perpendicular to the motion of a particle, then its
   (1) Speed is uniform (2) Momentum is uniform (3) Velocity is uniform (4) All of these

Sol. Answer (1)

No component of force is in the direction of motion (as $\vec{F} \perp \vec{V}$) so it cannot change the speed of particle. But velocity cannot be constant because force will change the direction of motion.

7. When a force of constant magnitude and a fixed direction acts on a moving object, then its path is
   (1) Circular (2) Parabolic (3) Straight line (4) Either (2) or (3)

Sol. Answer (4)

1. To move a particle in circular motion centripetal force is required which has variable direction.
2. Parabolic is possible (example projectile motion)
3. If force is in the direction of motion or just opposite to it, path will be straight line

8. A 10 g bullet moving at 200 m/s stops after penetrating 5 cm of wooden plank. The average force exerted on the bullet will be
   (1) 2000 N (2) –2000 N (3) 4000 N (4) –4000 N

Sol. Answer (4)

m = 10 g, u = 200 m/s, s = 5 cm

final velocity $v = 0$

Using $v^2 = u^2 + 2as$

$$a = \frac{u^2}{2s}$$

and for force $F = -\, ma$ (retarding force)

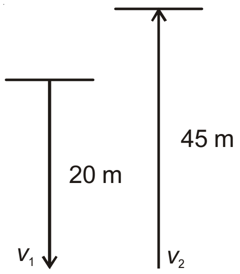
9. A ball of mass 50 g is dropped from a height of 20 m. A boy on the ground hits the ball vertically upwards with a bat with an average force of 200 N, so that it attains a vertical height of 45 m. The time for which the ball remains in contact with the bat is [Take g = 10 m/s^2]
   (1) 1/20th of a second (2) 1/40th of a second (3) 1/80th of a second (4) 1/120th of a second

Sol. Answer (3)

Using $v^2 = u^2 + 2as$

$v_1 = \sqrt{2g\,(20)} = 20$ m/s

$v_2 = \sqrt{2g(45)} = 30$ m/s



Impulse = $F\Delta t = m(\vec{v}_2 - \vec{v}_1)$

$\Rightarrow 200\ t = \dfrac{50}{1000}\ (20 - (-30))$

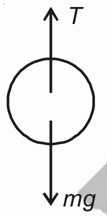
$t = \dfrac{5}{400} = \dfrac{1}{80}$ s

10. A string tied on a roof can bear a maximum tension of 50 kg wt. The minimum acceleration that can be acquired by a man of 98 kg to descend will be [Take g = 9.8 m/s^2]

(1) 9.8 m/s^2 (2) 4.9 m/s^2 (3) 4.8 m/s^2 (4) 5 m/s^2

Sol. Answer (3)

T_{max} = 50 g = 50 × 9.8 = 490 N



Using $F_{net} = ma$

98g – 50g = 98a

a = 4.8 m/s^2

11. When a 4 kg rifle is fired, the 10 g bullet receives an acceleration of 3 × 10^6 cm/s^2. The magnitude of the force acting on the rifle (in newton) is

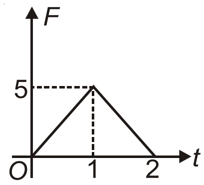
(1) Zero (2) 120 (3) 300 (4) 3000

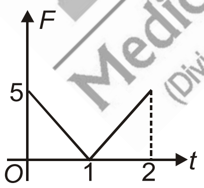
Sol. Answer (3)

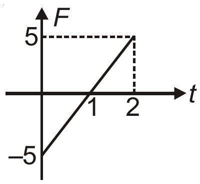
Using Newton's third law, bullet will apply the same force in the opposite direction.

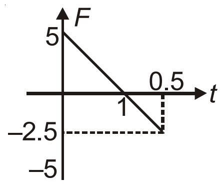
So, using $F = ma = \dfrac{10}{1000} \times 3 \times 10^6 \times 10^{-2} = 300$ N

12. In which of the following graphs, the total change in momentum is zero?

(1) 

(2) 

(3) 

(4) 

Sol. Answer (3)

Total change in momentum = $\int F.dt$ = Area under Ft curve.

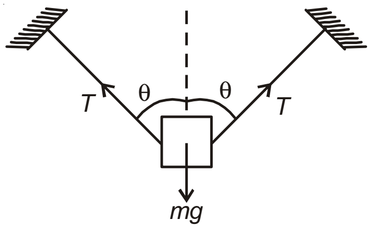
Area above t-axis will be positive and below t-axis will be negative in option (3)

Area $= -\left[\dfrac{1}{2} \times 5 \times 1\right] + \dfrac{1}{2} \times 5 \times 1 = 0$

13. A weight Mg is suspended from the middle of a rope whose ends are at the same level. The rope is no longer horizontal. The minimum tension required to completely straighten the rope is

(1) $\dfrac{Mg}{2}$ (2) $Mg\cos\theta$ (3) $2Mg\cos\theta$ (4) Infinitely large

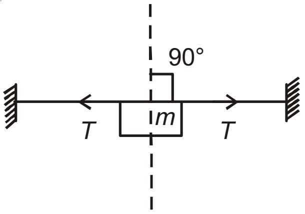
Sol. Answer (4)



$2T\cos\theta = mg$

$$T = \frac{mg}{2\cos\theta} \qquad \ldots\text{(i)}$$

To make this string completely straight

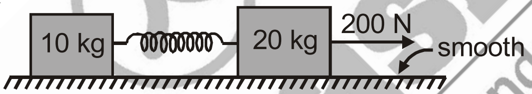


$\theta = 90°$

in (i) put $\theta = 90°$

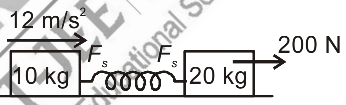
$$T = \frac{mg}{2\cos 90°} \approx \infty$$

14. Two masses of 10 kg and 20 kg respectively are connected by a massless spring as shown in fig. A force of 200 N acts on the 20 kg mass. At the instant shown the 10 kg mass has acceleration 12 m/s^2 towards right. The acceleration of 20 kg mass at this instant is



(1) 12 m/s^2 (2) 4 m/s^2 (3) 10 m/s^2 (4) Zero

Sol. Answer (2)



F_s is spring force

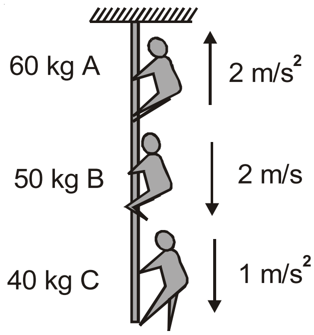
$F_s = 10 \times 12 = 120$ N

for 20 kg block

$200 - 120 = 20a$

$$a = \frac{80}{20} = 4 \text{ m/s}^2$$

15. Tension in the rope at the rigid support is (g = 10 m/s^2)



(1) 760 N (2) 1360 N

(3) 1580 N (4) 1620 N

Sol. Answer (3)

For 40 kg, $400 - T_1 = 40$ (1)

$\Rightarrow T_1 = 360$ N

For 50 kg, $500 + T_1 - T_2 = 50$ (2)

$\Rightarrow T_2 = 760$ N

For 60 kg $\Rightarrow T_3 - 600 - T_2 = 60$ (3)

$T_3 = 1580$ N

T_3 will be the tension at the topmost point on the rigid support.

16. Two bodies of masses m_1 and m_2 are connected by a light string which passes over a frictionless, massless pulley. If the pulley is moving upward with uniform acceleration $\frac{g}{2}$, then tension in the string will be

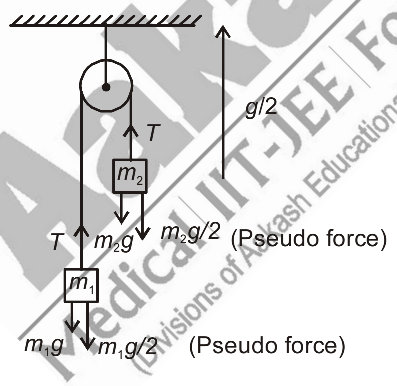
(1) $\frac{3m_1m_2}{m_1+m_2}g$

(2) $\frac{m_1+m_2}{4m_1m_2}g$

(3) $\frac{2m_1m_2}{m_1+m_2}g$

(4) $\frac{m_1m_2}{m_1+m_2}g$

Sol. Answer (1)



Writing equation from the reference frame of pulley

$$\frac{3m_1g}{2} - T = m_1a \quad \text{...(i)}$$

$$T - \frac{3m_2g}{2} = m_2a \quad \text{...(ii)}$$

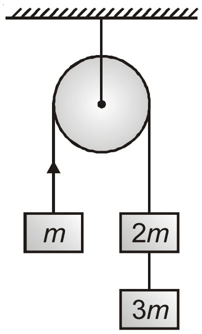
Add (i) and (ii)

$$\frac{3g}{2}\left(\frac{m_1 - m_2}{m_1 + m_2}\right) = a$$

Use a in eq. (i) or (ii)

Solving $T = \frac{3m_1m_2}{m_1+m_2}g$

17. In the figure given below, with what acceleration does the block of mass m will move? (Pulley and strings are massless and frictionless)



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

Sol. Answer (3)

For the single pulley system $a = \left(\frac{m_1 - m_2}{m_1 + m_2}\right)g$

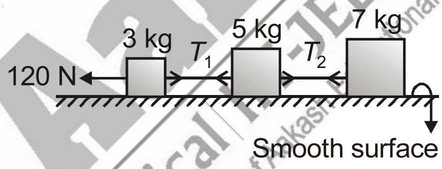
take $2m$ and $3m$ as a system (*i.e.,* single block of $5m$ mass)

$m_1 = 5m$

$m_2 = m$

$a = \left(\frac{5m - m}{5m + m}\right) g = \frac{2g}{3}$

18. T_1 and T_2 in the given figure are

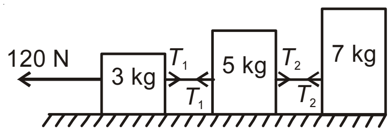


(1) 28 N, 48 N
(2) 48 N, 28 N
(3) 96 N, 56 N
(4) 56 N, 96 N

Sol. Answer (3)

Acceleration of the system $a = \frac{F_{ext}}{M_{Total}} = \frac{120}{3+5+7} = 8\ \text{m/s}^2$

Writing equation for 7 kg mass



$T_2 = 7(8)$

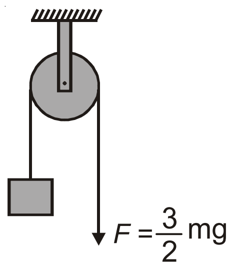
$= 56$ N

Writing equation for 5 kg mass

$T_1 = T_2 + 5\ (a)$

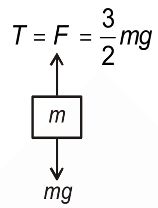
$= 56 + 5\ (8) = 96$ N

19. In the arrangement shown, the mass *m* will ascend with an acceleration (Pulley and rope are massless)



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

Sol. Answer (2)



$F_{net} = ma$

$\frac{3}{2}mg - mg = ma$

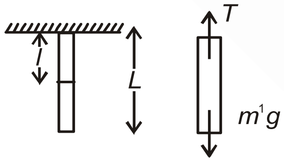
$a = g/2$

20. A uniform rope of mass *M* and length *L* is fixed at its upper end vertically from a rigid support. Then the tension in the rope at the distance *l* from the rigid support is

(1) $Mg\frac{L}{L+l}$ (2) $\frac{Mg}{L}(L-l)$ (3) Mg (4) $\frac{l}{L}Mg$

Sol. Answer (2)

For the lower part



Mass of the lower part is m'

m' = Mass per unit length × length of lower part

$= \frac{M}{L}(L-l)$

So, Using $\vec{F}_{net} = m\vec{a}$

here $\vec{a} = 0$

$T - \frac{M}{L}(L-l)\,g = 0$

$T = \frac{M}{L}(L-l)\,g$

21. A man slides down a light rope whose breaking strength is η times the weight of man ($\eta < 1$). The maximum acceleration of the man so that the rope just breaks is

(1) $g(1-\eta)$ (2) $g(1+\eta)$ (3) $g\eta$ (4) $\frac{g}{\eta}$

Sol. Answer (1)

Given that $T_{max} = \eta\, w$

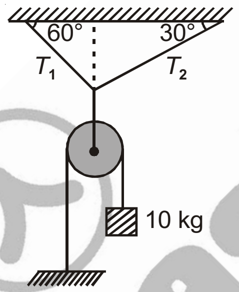
Using $F_{net} = ma$

$w - T_{max} = \frac{w}{g}a$

$T_{max} = \eta\, w$

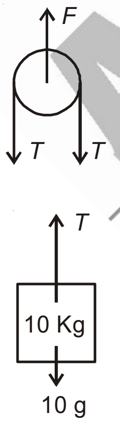
So $a = g(1-\eta)$

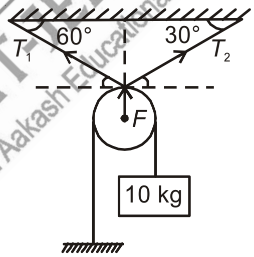
22. In the arrangement as shown, tension T_2 is (g = 10 m/s^2)



(1) 50 N (2) 100 N (3) $50\sqrt{3}$ N (4) $100\sqrt{3}$ N

Sol. Answer (2)





For pulley

$F = 2T$

for block

$T = 10\,g = 100$ N

$F = 200$ N

For horizontal equilibrium

$T_1 \cos 60° = T_2 \cos 30°$

$T_1 = 2T_2 \frac{\sqrt{3}}{2} = \sqrt{3}\, T_2$ ...(i)

For vertical equilibrium

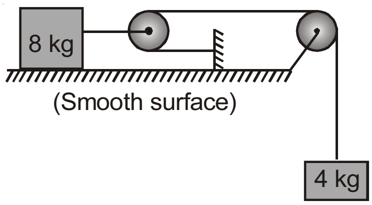
$T_1 = \sin 60° + T_2 \sin 30° = 200$ ...(ii)

Using (i) and (ii) solve for T_2

$2T_2 = 200$

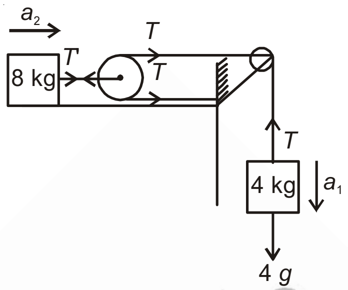
$T_2 = 100$ N

23. If pulleys shown in the diagram are smooth and massless and a_1 and a_2 are acceleration of blocks of mass 4 kg and 8 kg respectively, then



(1) $a_1 = a_2$ (2) $a_1 = 2a_2$ (3) $2a_1 = a_2$ (4) $a_1 = 4a_2$

Sol. Answer (2)



For 8 kg $T' = 8a_1$ ...(i)

for 4 kg

$4g - T = 4a_2$ ...(ii)

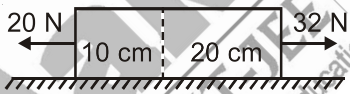
for pulley

$T^1 = 2T$ ...(iii)

Using (i), (ii) and (iii)

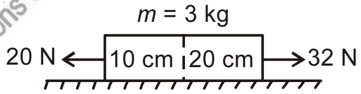
$a_2 = \dfrac{a_1}{2}$

24. Figure shows a uniform rod of length 30 cm having a mass 3.0 kg. The rod is pulled by constant forces of 20 N and 32 N as shown. Find the force exerted by 20 cm part of the rod on the 10 cm part (all surfaces are smooth) is



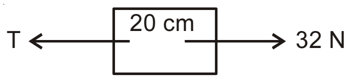
(1) 36 N (2) 12 N (3) 64 N (4) 24 N

Sol. Answer (4)



Acceleration of the system = $\dfrac{\vec{F}_{net}}{m}$

$= \dfrac{32-20}{3} = 4\ m/s^2$



Free body diagram of 20 cm part

Mass of 20 cm part $m' = \dfrac{\text{Total mass}}{\text{Total length}} \times (20\text{ cm})$

$= \dfrac{3}{30}(20) = 2\text{ kg}$

Using equation $\vec{F}_{net} = m'a$

$32 - T = 2(4)$

$T = 24$ N

25. In a rocket, fuel burns at the rate of 2 kg/s. This fuel gets ejected from the rocket with a velocity of 80 km/s. Force exerted on the rocket is

(1) 16,000 N (2) 1,60,000 N (3) 1600 N (4) 16 N

Sol. Answer (2)

For variable mass system $F = \frac{u\,dm}{dt} = 80 \times 10^3 \times 2 = 1{,}60{,}000$ N

26. A machine gun fires a bullet of mass 65 g with a velocity of 1300 m/s. The man holding it can exert a maximum force of 169 N on the gun. The number of bullets he can fire per second will be

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

Sol. Answer (2)

$nmv = F$

n is number of bullets fired per second

$$n\left[\frac{65}{1000}.1300\right] = 169$$

$$n = 2$$

27. A rocket of mass 5700 kg ejects mass at a constant rate of 15 kg/s with constant speed of 12 km/s. The acceleration of the rocket 1 minute after the blast is (g = 10 m/s^2)

(1) 34.9 m/s^2 (2) 27.5 m/s^2 (3) 3.50 m/s^2 (4) 13.5 m/s^2

Sol. Answer (2)

$$F = \frac{vdm}{dt} - mg \quad \text{...(i)}$$

where m is mass of the rocket after 1 minute

So m = [5700 – 15 (60)] = 4800 kg

in (i)

$$F = (12 \times 10^3)(15) - (4800)\,g$$

$$= (12000)(15) - 48000$$

$$a = \frac{F}{m} = \frac{12000(15) - 48000}{4800}$$

$$= 27.5 \text{ m/s}^2$$

28. A balloon has 2 g of air. A small hole is pierced into it. The air comes out with a velocity of 4 m/s. If the balloon shrinks completely in 2.5 s. The average force acting on the balloon is

(1) 0.008 N (2) 0.0032 N (3) 8 N (4) 3.2 N

Sol. Answer (2)

$$F = \frac{vdm}{dt}$$

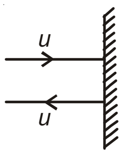
$$= 4\left(\frac{2}{1000 \times 2.5}\right) = 0.0032 \text{ N}$$

29. If n balls hit elastically and normally on a surface per unit time and all balls of mass m are moving with same velocity u, then force on surface is

(1) mun (2) $2\ mun$ (3) $\frac{1}{2}mu^2n$ (4) mu^2n

Sol. Answer (2)

As collision is elastic, velocity after the collision will be $-u$

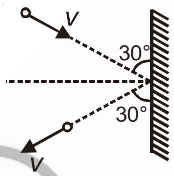


So using $F = \frac{dp}{dt}$

$= n(mu - (-mu))$

$= 2nmu$

30. A particle of mass m strikes a wall with speed v at an angle 30° with the wall elastically as shown in the figure. The magnitude of impulse imparted to the ball by the wall is



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

Sol. Answer (1)

Impulse = change in momentum

applying equation of change in momentum in horizontal direction

$I = mv\sin30° - (-mv\sin30°)$

$= 2mv\left(\frac{1}{2}\right) = mv$

(Newton's Third Law of Motion Conservation of Momentum)

31. In accordance with Newton's third law of motion

(1) Action and reaction never balance each other

(2) For appearance of action and reaction, physical contact is not necessary

(3) This law is applicable whether the bodies are at rest or they are in motion

(4) All of these

Sol. Answer (4)

(1) Action and reaction act on the different bodies.

(2) Example : Gravitational force, coulomb force

(3) 3rd law is irrespective of the state of motion

32. A bullet of mass 40 g is fired from a gun of mass 10 kg. If velocity of bullet is 400 m/s, then the recoil velocity of the gun will be

(1) 1.6 m/s in the direction of bullet
(2) 1.6 m/s opposite to the direction of bullet
(3) 1.8 m/s in the direction of bullet
(4) 1.8 m/s opposite to the direction of bullet

Sol. Answer (2)

Using conservation of momentum

$P_i = P_f$ ...(i)

$P_i = 0$

$P_f = \frac{40}{1000}(400) + 10v$

So in (i)

$0 = \frac{40}{1000}(400) + 10v$

$v = -1.6$ m/s

33. A cracker rocket is ejecting gases at a rate of 0.05 kg/s with a velocity 400 m/s. The accelerating force on the rocket is

(1) 20 dyne (2) 20 N (3) 200 N (4) Zero

Sol. Answer (2)

For a variable mass system

$F = \frac{vdm}{dt}$

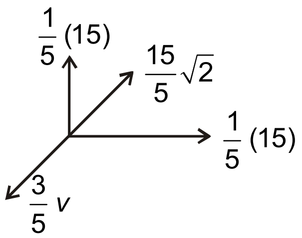
$= 400 \times 0.05 = 20$ N

34. A bomb of mass 1 kg initially at rest, explodes and breaks into three fragments of masses in the ratio 1 : 1 : 3. The two pieces of equal mass fly off perpendicular to each other with a speed 15 m/s each. The speed of heavier fragment is

(1) 5 m/s (2) 15 m/s (3) 45 m/s (4) $5\sqrt{2}$ m/s

Sol. Answer (4)

Momentum of the system will be conserved before explosion and after explosion



Using conservation of momentum equation

$\frac{3}{5}V = \frac{15}{5}\sqrt{2}$

$V = 5\sqrt{2}$ m/s

35. A 6 kg bomb at rest explodes into three equal pieces *P*, *Q* and *R*. If *P* flies with speed 30 m/s and *Q* with speed 40 m/s making an angle 90° with the direction of *P*. The angle between the direction of motion of *P* and *R* is about

(1) 143° (2) 127°

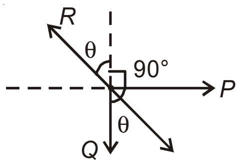
(3) 120° (4) 150°

Sol. Answer (2)

$P_p = 30(2) = 60$ kg ms^{-1}

$P_Q = 40\ (2) = 80$ kg ms^{-1}

$\tan\theta = \dfrac{60}{80} = 3/4$



$\theta = 37°$

So angle between P and R will be 90° + 37° = 127°

36. A particle of mass $2m$ moving with velocity v strikes a stationary particle of mass $3m$ and sticks to it. The speed of the system will be

(1) $0.8v$ (2) $0.2v$ (3) $0.6v$ (4) $0.4v$

Sol. Answer (4)

Collision is completely inelastic using momentum conservation

$2mv + 0 = (2m + 3m)v'$

$v' = \dfrac{2v}{5} = 0.4v$

(Common Forces in Mechanics)

37. A man of mass 50 kg carries a bag of weight 40 N on his shoulder. The force with which the floor pushes up his feet will be

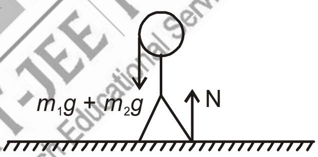
(1) 882 N (2) 530 N (3) 90 N (4) 600 N

Sol. Answer (2)

$N = m_1g + m_2g$

$= 50\ (9.8) + 40$

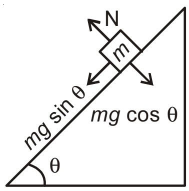
$= 490 + 40 = 530$ N



38. A block of mass m is released on a smooth inclined plane of inclination θ with the horizontal. The force exerted by the plane on the block has a magnitude

(1) mg (2) $\dfrac{mg}{\cos\theta}$ (3) $mg\tan\theta$ (4) $mg\cos\theta$

Sol. Answer (4)



Force enerted by the plane on the block will be N

$N = mg\cos\theta$

39. Which of the following is self-adjusting force?

(1) Static friction (2) Limiting friction

(3) Kinetic friction (4) Rolling friction

Sol. Answer (1)

Static friction is self adjusting force. Its value varies from $0 \le f_s \le \mu_s N$

40. Maximum force of friction is called

(1) Limiting friction (2) Static friction (3) Sliding friction (4) Rolling friction

Sol. Answer (1)

Limiting friction is maximum force of friction.

41. The limiting friction between two bodies in contact is independent of

(1) Nature of the surface in contact (2) The area of surfaces in contact

(3) Normal reaction between the surfaces (4) The materials of the bodies

Sol. Answer (2)

42. It is difficult to move a cycle with brakes on because

(1) Rolling friction opposes motion on road (2) Sliding friction opposes motion on road

(3) Rolling friction is more than sliding friction (4) Sliding friction is more than the rolling friction

Sol. Answer (4)

Sliding friction > Rolling friction

43. Which is a suitable method to decrease friction?

(1) Polishing (2) Lubrication (3) Ball bearing (4) All of these

Sol. Answer (4)

44. A cubical block rests on a plane of $\mu = \sqrt{3}$. The angle through which the plane be inclined to the horizontal so that the block just slides down will be

(1) 30° (2) 45° (3) 60° (4) 75°

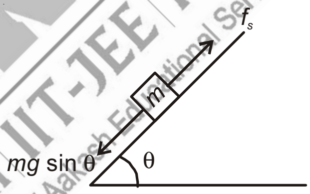
Sol. Answer (3)

$f_s = mg \sin \theta$

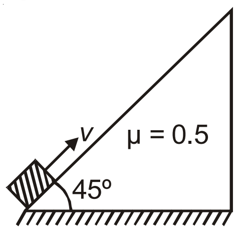
$\mu\, mg \cos \theta = mg \sin \theta$

$\tan \theta = \mu = \sqrt{3}$

$\theta = 60°$



45. A block of mass 1 kg is projected from the lowest point up along the inclined plane. If $g = 10\ ms^{-2}$, the retardation experienced by the block is



(1) $\frac{15}{\sqrt{2}}\ ms^{-2}$ (2) $\frac{5}{\sqrt{2}}\ ms^{-2}$

(3) $\frac{10}{\sqrt{2}}\ ms^{-2}$ (4) Zero

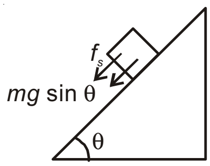
Sol. Answer (1)

Retarding forces will be friction and gravitational force

$a = -(g \sin 45° + \mu\, g \cos 45°)$

$= -\left(\frac{10}{\sqrt{2}} + (0.5)\frac{(10)}{\sqrt{2}}\right)$

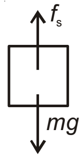
$= \frac{15}{\sqrt{2}}$



46. A child weighing 25 kg slides down a rope hanging from a branch of a tall tree. If the force of friction acting against him is 200 N, the acceleration of child is (g = 10 m/s^2)

(1) 22.5 m/s^2 (2) 8 m/s^2 (3) 5 m/s^2 (4) 2 m/s^2

Sol. Answer (4)



$mg - f_s = ma$

$250 - 200 = 25a$

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

47. An object of mass 1 kg moving on a horizontal surface with initial velocity 8 m/s comes to rest after 10s. If one wants to keep the object moving on the same surface with velocity 8 m/s the force required is

(1) 0.4 N (2) 0.8 N (3) 1.2 N (4) Zero

Sol. Answer (2)

To find the frictional force offered by the ground

$v = u + at$

$v = 0$

$0 = 8 - \mu g\,(10)$

$\mu = \frac{8}{100} = 0.08$

To move the body with constant velocity on this surface, internal force applied should be equal to friction force
$F = \mu mg$

$= (0.08)\,(1)\,(10) = 0.8$ N

48. A heavy box is solid across a rough floor with an initial speed of 4 m/s. It stops moving after 8 seconds. If the average resisting force of friction is 10 N, the mass of the box (in kg) is

(1) 40 (2) 20 (3) 5 (4) 2.5

Sol. Answer (2)

Same like previous question

$\mu = \frac{4}{80} = 0.05$

$F = \mu\, mg$

$10 = 0.5m$

$m = 20$ kg

49. If a block moving up an inclined plane at 30° with a velocity of 5 m/s, stops after 0.5 s, then coefficient of friction will be nearly

(1) 0.5 (2) 0.6 (3) 0.9 (4) 1.1

Sol. Answer (2)

Using $v = u + at$

Retardation will be provided by friction as well as gravitational force

$$a = \frac{u}{t}$$

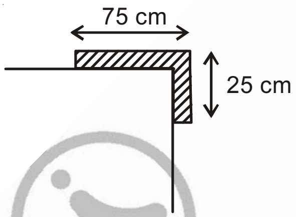
$$g \sin 30° + \mu g \cos 30° = \frac{5}{0.5} = 10$$

$$\mu = \frac{1}{\sqrt{3}} \cong 0.6$$

50. A metallic chain 1m long lies on a horizontal surface of a table. The chain starts sliding on the table if 25 cm (or more of it) hangs over the edge of a table. The correct value of the coefficient of friction between the table and the chain is

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

Sol. Answer (1)



$$\frac{M}{4}g = \frac{\mu 3M}{4}g$$

$$\mu = 1/3$$

51. A block of mass m placed on an inclined plane of angle of inclination θ slides down the plane with constant speed. The coefficient of kinetic friction between block and inclined plane is

(1) $\sin\theta$ (2) $\cos\theta$ (3) $\tan\theta$ (4) $\cot\theta$

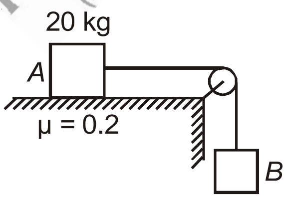
Sol. Answer (3)

Sliding with constant velocity implies that net force acting on the block is zero. So,

$$\mu\, mg \cos\theta = mg \sin\theta$$

$$\mu = \tan\theta$$

52. In the figure shown, the coefficient of static friction between the block A of mass 20 kg and horizontal table is 0.2. What should be the minimum mass of hanging block just beyond which blocks start moving?



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

Sol. Answer (3)

Tension produced in the string should be just greater than the frictional force acting on the 20 kg block

$T = m_B g$

$T > \mu\, m_A g$

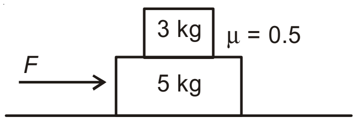
$m_B g > (0.2)\ (20\ (g)$

$m_B > 4$ kg

53. Two blocks A and B of masses 5 kg and 3 kg respectively rest on a smooth horizontal surface with B over A. The coefficient of friction between A and B is 0.5. The maximum horizontal force (in kg wt.) that can be applied to A, so that there will be motion of A and B without relative slipping, is

(1) 1.5 (2) 2.5 (3) 4 (4) 5

Sol. Answer (3)



It both are moving together

$a = \dfrac{F}{8}$

For 3 kg block, $f = 3\left(\dfrac{F}{8}\right)$

$(0.5\ (3)\ g = \dfrac{3F}{8} \Rightarrow F = 40$ N

So, m = 4 kg

(Equilibrium of a Particle Frame of Reference)

54. When an object is at rest

(1) Force is required to keep it in rest state

(2) No force is acting on it

(3) A large number of forces may be acting on it which balance each other

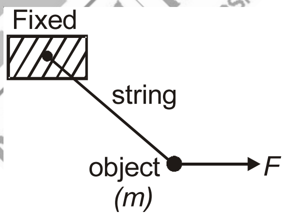
(4) It is in vacuum

Sol. Answer (3)

Object can be at rest only if net force acting on it is zero.

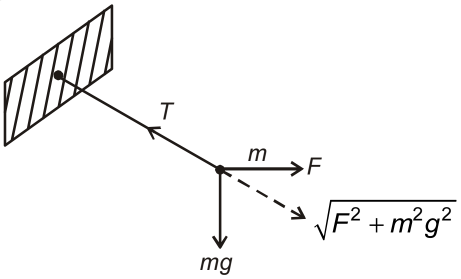
$\vec{F}_{net} = \vec{F}_1 + \vec{F}_2 + \vec{F}_3 + \vec{F}_4 + ... \vec{F}_n = 0$

55. In the following figure, the object of mass m is held at rest by a horizontal force as shown. The force exerted by the string on the block is



(1) F (2) mg (3) $F + mg$ (4) $\sqrt{F^2 + m^2g^2}$

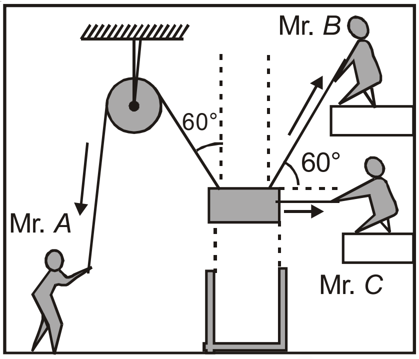
Sol. Answer (4)



For mass m to be at rest, net force on m should be zero

So $T = \sqrt{F^2 + m^2g^2}$

56. Mr. *A*, *B* and *C* are trying to put a heavy piston into a cylinder at a mechanical workshop in railway yard. If they apply forces F_1, F_2 and F_3 respectively on ropes then for which set of forces at that instant, they will be able to perform the said job?



(1) $\sqrt{3}F_1 = F_2 + 2F_3$ (2) $2F_1 = F_2 + F_3$ (3) $2F_2 = \sqrt{3}F_1 - \frac{F_3}{2}$ (4) $F_3 = 2F_1 - \sqrt{3}F_2$

Sol. Answer (1)

Piston is vertically above the cylinder so to drop it inside the cylinder, Net horizontal force must be zero on the piston

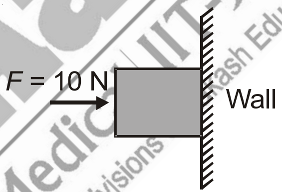
So,

$F_1 \sin 60 = F_2 \cos 60 + F_3$

$F_1 \frac{\sqrt{3}}{2} = \frac{F_2}{2} + F_3$

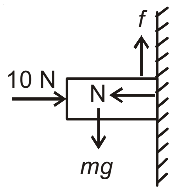
$\sqrt{3}F_1 = F_2 + 2F_3$

57. A horizontal force 10 N is necessary to just hold a block stationary against a wall. The coefficient of friction between the block and the wall is 0.2, the weight of the block is



(1) 20 N (2) 50 N (3) 100 N (4) 2 N

Sol. Answer (4)



Normal reaction N = 10 newton

in vertical direction frictional force will balance its weight

$f = mg = W$

$\mu N = (0.2)(10) = 2$ newton

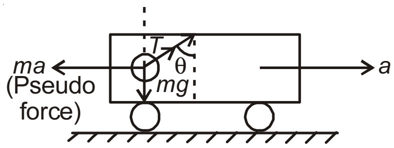
58. A small metallic sphere of mass *m* is suspended from the ceiling of a car accelerating on a horizontal road with constant acceleration *a*. The tension in the string attached with metallic sphere is

(1) mg (2) $m(g + a)$ (3) $m(g - a)$ (4) $m\sqrt{g^2 + a^2}$

Sol. Answer (4)

$T \cos \theta = mg$ ...(i)

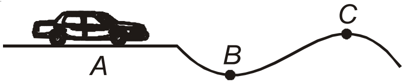
$T \sin \theta = ma$ ...(ii)



Square and add (i) and (ii)

$T = m\sqrt{a^2 + g^2}$

59. A vehicle is moving on a track with constant speed as shown in figure. The apparent weight of the vehicle is



(1) Maximum at A
(2) Maximum at B
(3) Maximum at C
(4) Same at A, B and C

Sol. Answer (2)

at A $N = mg$

at B $N - mg = \frac{mv^2}{r}$

$N = mg + \frac{mv^2}{r}$

at C $mg - N = \frac{mv^2}{r}$

$N = mg - \frac{mv^2}{r}$

So, at B, N is maximum. Hence apparent weight of the vechicle is maximum at B

(Circular Motion Solving Problems in Mechanics)

60. A cyclist riding the bicycle at a speed of $14\sqrt{3}$ m/s takes a turn around a circular road of radius $20\sqrt{3}$ m without skidding. What is his inclination to the vertical?

(1) 30° (2) 45° (3) 60° (4) 75°

Sol. Answer (3)

$\tan \theta = \frac{v^2}{rg}$

$= \frac{14 \times 14 \times 3}{20\sqrt{3} \times 10} \simeq \sqrt{3}$

$\theta = 60°$

61. A bus turns a slippery road having coefficient of friction of 0.5 with a speed of 10 m/s. The minimum radius of the arc in which bus turns is [Take g = 10 m/s^2]

(1) 4 m
(2) 10 m
(3) 15 m
(4) 20 m

Sol. Answer (4)

$\frac{v^2}{r} = \mu g$

$\frac{10 \times 10}{r} = 0.5 \times 10$

$r = 20$ m

62. A car is moving on a horizontal circular track of radius 0.2 km with a constant speed. If coefficient of friction between tyres of car and road is 0.45, then maximum speed of car may be [Take g = 10 m/s^2]

(1) 15 m/s (2) 30 m/s (3) 20 m/s (4) 40 m/s

Sol. Answer (2)

$$\frac{v^2}{r} = \mu g$$

$$\frac{v^2}{0.2\times10^3} = 4.5$$

$v = \sqrt{900} = 30$ m/s

63. A boy is sitting on the horizontal platform of a joy wheel at a distance of 5 m from the center. The wheel begins to rotate and when the angular speed exceeds 1 rad/s, the boy just slips. The coefficient of friction between the boy and the wheel is (g = 10 m/s^2)

(1) 0.5 (2) 0.32 (3) 0.71 (4) 0.2

Sol. Answer (1)

$$\frac{v^2}{r} = \omega^2 r = \mu\, g$$

$m = 0.5$

64. A train is running at 20 m/s on a railway line with radius of curvature 40,000 metres. The distance between the two rails is 1.5 metres. For safe running of train the elevation of outer rail over the inner rail is (g = 10 m/s^2)

(1) 2.0 mm (2) 1.75 mm

(3) 1.50 mm (4) 1.25 mm

Sol. Answer (3)

$$\tan\theta = \frac{h}{d} = \frac{v^2}{rg}$$

$$h = \frac{(1.5)(20)(20)}{40,000\times10}$$

$= 1.5$ mm

65. A car is moving on a horizontal circular road of radius 0.1 km with constant speed. If coefficient of friction between tyres of car and road is 0.4, then speed of car may be (g = 10 m/s^2)

(1) 5 m/s (2) 10 m/s

(3) 20 m/s (4) All of these

Sol. Answer (4)

Maximum speed for the circular road

$$\frac{v^2_{\text{maximum}}}{r} = \mu g$$

$$V_{\text{maximum}} = \sqrt{\mu r g}$$

$$= \sqrt{0.4\times100\times10} = \sqrt{400} = 20 \text{ m/s}$$

SECTION - B

Objective Type Questions

(Newton's Second Law of Motion)

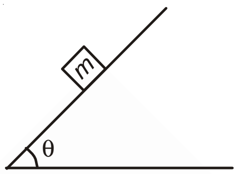
1. A block of weight 1 N rests on an inclined plane of inclination θ with the horizontal. The coefficient of friction between the block and the inclined plane is μ. The minimum force that has to be applied parallel to the inclined plane to make the body just move up the plane is

(1) $\mu \sin\theta$ (2) $\mu \cos\theta$ (3) $\mu \cos\theta - \sin\theta$ (4) $\mu \cos\theta + \sin\theta$

Sol. Answer (4)

Given mg = 1 N

To just move the body up



F = friction force + gravitation force

$= \mu\, mg \cos\theta + mg \sin\theta$

$= \mu \cos\theta + \sin\theta$

2. If a pushing force making an angle α with horizontal is applied on a block of mass m placed on horizontal table and angle of friction is β, then minimum magnitude of force required to move the block is

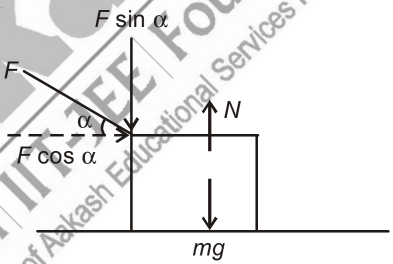
(1) $\dfrac{mg\sin\beta}{\cos[\alpha-\beta]}$ (2) $\dfrac{mg\sin\beta}{\cos[\alpha+\beta]}$ (3) $\dfrac{mg\sin\beta}{\sin[\alpha+\beta]}$ (4) $\dfrac{mg\cos\beta}{\cos[\alpha-\beta]}$

Sol. Answer (2)

Angle of friction is β

$\Rightarrow \mu = \tan\beta$

$N = mg + F\sin\alpha$



To just move the block

$F\cos\alpha = \mu N$

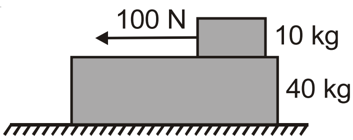
$F\cos\alpha = \tan\beta\,(mg + F\sin\alpha)$

$F(\cos\alpha - \tan\beta\sin\alpha) = mg\tan\beta$

$F(\cos\alpha\cos\beta - \sin\alpha\sin\beta) = mg\sin\beta$

$F = \dfrac{mg\sin\beta}{\cos(\alpha+\beta)}$

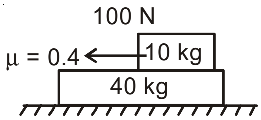
3. A 40 kg slab rests on a frictionless floor. A 10 kg block rests on top of the slab. The coefficient of friction between the block and the slab is 0.40. The 10 kg block is acted upon by a horizontal force of 100 N. If g = 10 m/s^2, the resulting acceleration of the slab will be



(1) 1.0 m/s^2 (2) 1.47 m/s^2 (3) 1.52 m/s^2 (4) 6.1 m/s^2

Sol. Answer (1)

Maximum external force when blocks move together = $\frac{f_{max}}{40}(40+10) = 50\text{ N}$



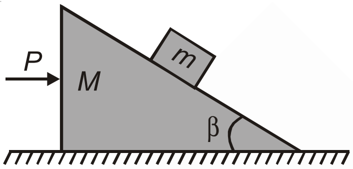
Now since external force is 100 N (which is > 50 N)

$\Rightarrow$ blocks will not move together. Hence net force acting on 40 kg will be only friction force

So using $F_{net} = ma$

$40 = (40\ a) \Rightarrow a = 1\text{ m/s}^2$

4. A block of mass m, is kept on a wedge of mass M, as shown in figure such that mass m remains stationary w.r.t. wedge. The magnitude of force P is



(1) $g \tan \beta$ (2) $mg \tan \beta$ (3) $(m + M)g \tan \beta$ (4) $mg \cot \beta$

Sol. Answer (3)

If acceleration of the system is a then $P = (M + m)\ a$

from the reference frame of wedge

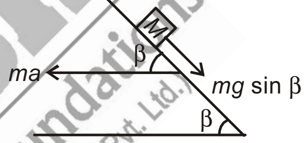
Component of ma along the inclined will be $ma \cos \beta$

for the block to be in equilibrium w.r.t. wedge

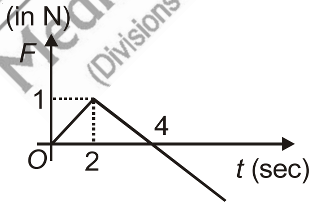
$ma \cos \beta = mg \sin \beta$

$a = g \tan \beta$

hence $P = (M + m)\ g \tan \beta$



5. Force acting on a body varies with time as shown below. If initial momentum of the body is $\vec{p}$, then the time taken by the body to retain its momentum $\vec{p}$ again is

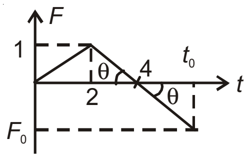


(1) 8 s (2) $(4+2\sqrt{2})$ s (3) 6 s (4) Can never obtain

Sol. Answer (2)

$\tan \theta = \frac{1}{2} = \frac{F_0}{t_0 - 4}$

$\Rightarrow \quad F_0 = \frac{t_0 - 4}{2}$



Total change in momentum should be zero, then only it will retain its initial momentum.

So, positive area of $F - t$ curve should be equal to negative area of $F - t$ curve till time t_0.

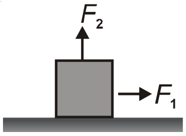
$$\frac{1}{2}(4)(1) = \frac{1}{2}\ (t_0 - 4)\ F_0$$

$$8 = \frac{(t_0 - 4)}{2} \cdot \frac{(t_0 - 4)}{2}$$

$$(t_0 - 4)^2 = 32$$

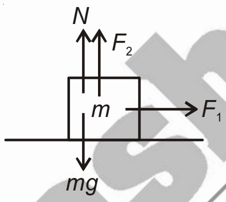
$$t_0 = 4 + 2\sqrt{2}$$

6. In the figure shown, horizontal force F_1 is applied on a block but the block does not slide. Then as the magnitude of vertical force F_2 is increased from zero the block begins to slide; the correct statement is



(1) The magnitude of normal reaction on block increases
(2) Static frictional force acting on the block increases
(3) Maximum value of static frictional force decreases
(4) All of these

Sol. Answer (3)



$N + F_2 = mg$

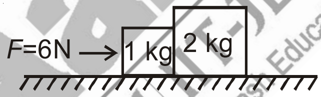
$N = mg - F_2$

As F_2 increases N will decrease

Static friction $f_s = \mu_s N = \mu_s\ (mg - F_2)$

$\Rightarrow$ By increasing F_2, f_s will decrease hence the block will slide

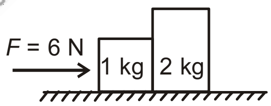
7. Arrangement of two block system is as shown. The net force acting on 1 kg and 2 kg blocks are (assuming the surfaces to be frictionless) respectively



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

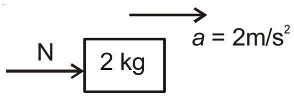
Sol. Answer (3)

Acceleration of the system $= \dfrac{F_{ext}}{M_{Total}}$



$= \dfrac{6}{3} = 2\ \text{m/s}^2$

for 2 kg block



$N = 2(2) = 4\text{N}$

for 1 kg block

$F_{net} = 6 - 4 = 2$ N

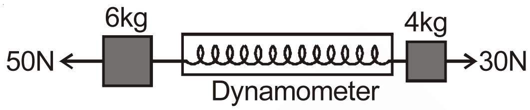
8. An open carriage in a goods train is moving with a uniform velocity of 10 m/s. If the rain adds water with zero velocity at the rate of 5 kg/s, then the additional force required by the engine to maintain the same velocity of the train is

(1) 0.5 N (2) 20 N (3) 50 N (4) Zero

Sol. Answer (3)

$$F_{(additional)} = \frac{vdm}{dt} = (10) \times 5 = 50 \text{ N}$$

9. A dynamometer *D* is attached to two blocks of masses 6 kg and 4 kg as shown in the figure. The reading of the dynamometer is



(1) 18 N (2) 28 N (3) 38 N (4) 48 N

Sol. Answer (3)

The tension in the spring will be the reading of dynamometer

$F)_{ext} = Ma$

$50–30 = 10(a)$

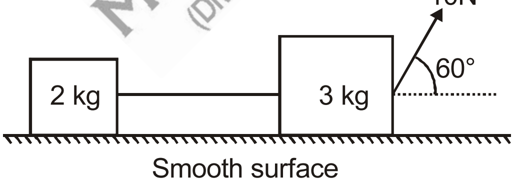
$a = 2 \text{ m/s}^2$

for 6 kg block

$50 - T = 6\ (2)$

$T = 38$ N

10. Figure shows two blocks connected by a light inextensible string as shown in figure. A force of 10 N is applied on the bigger block at 60° with horizontal, then the tension in the string connecting the two masses is



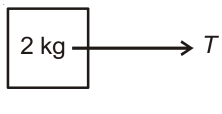
(1) 5 N (2) 2 N (3) 1 N (4) 3 N

Sol. Answer (2)

$F_{net} = Ma$

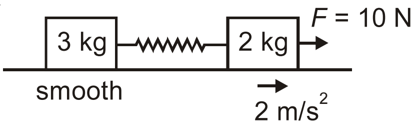
$(10 \cos 60°) = (3 + 2)\ a$

$a = 1 \text{ m/s}^2$



$T = 2(1) = 2$ N

11. What is the acceleration of 3 kg mass when acceleration of 2 kg mass is 2 m/s^2 as shown?

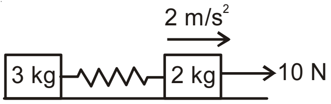


(1) 3 m/s^2 (2) 2 m/s^2 (3) 0.5 m/s^2 (4) Zero

Sol. Answer (2)

For 2 kg $10 - T = 2(2)$

$T = 10 - 4 = 6$ N

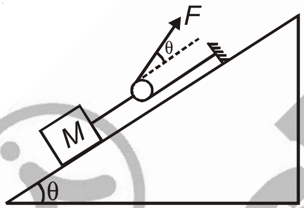


For 3 kg $T = 3(a)$

$6 = 3a$

$a = 2$ m/s^2

12. What is the minimum value of F needed so that block begins to move upward on frictionless incline plane as shown?

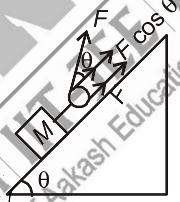


(1) $Mg\tan\left(\frac{\theta}{2}\right)$ (2) $Mg\cot\left(\frac{\theta}{2}\right)$ (3) $\frac{Mg\sin\theta}{(1+\sin\theta)}$ (4) $Mg\sin\left(\frac{\theta}{2}\right)$

Sol. Answer (1)

$F + F\cos\theta = mg\sin\theta$

$$F = \frac{mg\sin\theta}{1+\cos\theta}$$



$$F = \frac{mg\ 2\sin\frac{\theta}{2}\cos\frac{\theta}{2}}{2\cos^2\frac{\theta}{2}}$$

$\left(\because \sin\theta = 2\sin\frac{\theta}{2}.\cos\frac{\theta}{2} \text{ and } 1+\cos\theta = 2\cos^2\frac{\theta}{2}\right)$

$$= mg\tan\frac{\theta}{2}$$

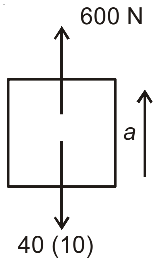
13. A monkey of mass 40 kg climbs up a rope, of breaking load 600 N hanging from a ceiling. If it climbs up the rope with the maximum possible acceleration, then the time taken by monkey to climb up is [Length of rope is 10 m]

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

Sol. Answer (1)

$600 - 400 = 40a$

$a = \frac{200}{40} = 5$ m/s^2

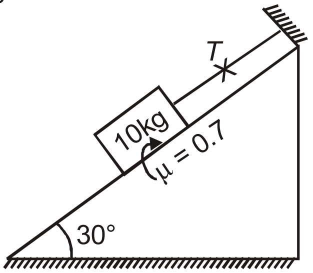


$S = ut + \frac{1}{2}at^2$

$10 = \frac{1}{2}(5)t^2$

$\Rightarrow$ $t = 2$ second

14. The tension T in the string shown in figure is



(1) Zero (2) 50 N (3) $35\sqrt{3}$ N (4) $(\sqrt{3}-1)\,50$ N

Sol. Answer (1)

$mg \sin\theta = 10\,(10)\sin 30° = 50$ N

Frictional force = $\mu\, mg \cos\theta = (0.7)(10)(10)\dfrac{\sqrt{3}}{2} = 35\sqrt{3}$ N

Frictional force is sufficient to oppose gravitational force. Tension will be zero.

15. An object of mass 2 kg at rest at origin starts moving under the action of a force

$$\vec{F} = (3t^2\hat{i} + 4t\hat{j})\ \text{N}$$

The velocity of the object at t = 2 s will be

(1) $(3\hat{i}+2\hat{j})$m/s (2) $(2\hat{i}+4\hat{j})$m/s (3) $(4\hat{i}+4\hat{j})$m/s (4) $(3\hat{i}-4\hat{j})$m/s

Sol. Answer (3)

$\vec{F} = 3t^2\hat{i} + 4t\hat{j}$

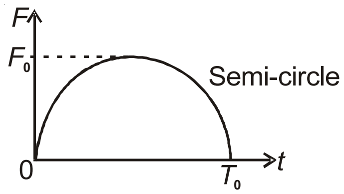
$P_2 - P_1 = \dfrac{3t^3}{3}\hat{i} + \dfrac{4t^2}{2}\hat{j}$

$P_1 = 0$

$(2)v = (2)^3\hat{i} + 2(2)^2\hat{j}$

$v = 4\hat{i} + 4\hat{j}$

16. The magnitude of force acting on a particle moving along x-axis varies with time (t) as shown in figure. If at t = 0 the velocity of particle is v_0, then its velocity at $t = T_0$ will be



(1) $v_0 + \dfrac{\pi F_0 T_0}{4m}$ (2) $v_0 + \dfrac{\pi F_0}{2m}$ (3) $v_0 + \dfrac{\pi T_0^2}{4m}$ (4) $v_0 + \dfrac{\pi F_0 T_0}{m}$

Sol. Answer (1)

$\int F dt = m\Delta v$

$\int F dt$ is area under F–t curve

$$m\Delta v = \pi\left(\frac{F_0}{2}\right).\left(\frac{T_0}{2}\right) \quad [\text{area} = \frac{\pi ab}{2}]$$

$$v - v_0 = \frac{\pi F_0 T_0}{4m}$$

$$v = v_0 + \frac{\pi F_0 T_0}{4m}$$

17. Three forces $\vec{F}_1 = (2\hat{i} + 4\hat{j})$ N ; $\vec{F}_2 = (2\hat{j} - \hat{k})$ N and $\vec{F}_3 = (\hat{k} - 4\hat{i} - 2\hat{j})$ N are applied on an object of mass 1 kg at rest at origin. The position of the object at $t = 2s$ will be

(1) (–2 m, –6 m) (2) (–4 m, 8 m) (3) (3 m, 6 m) (4) (2 m, –3 m)

Sol. Answer (2)

$$\vec{a} = \frac{\vec{F}_1 + \vec{F}_2 + \vec{F}_3}{1} = -2\hat{i} + 4\hat{j}$$

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

$$= \frac{1}{2}(-2\hat{i} + 4\hat{j})(2)^2$$

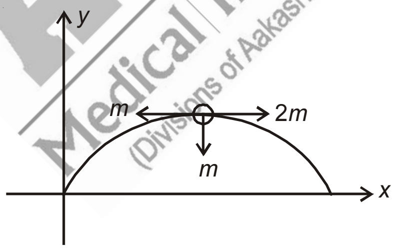
$$= -4\hat{i} + 8\hat{j}$$

(Newton's Third Law of Motion Conservation of Momentum)

18. A projectile is fired with velocity u at an angle θ with horizontal. At the highest point of its trajectory it splits up into three segments of masses m, m and 2 m. First part falls vertically downward with zero initial velocity and second part returns via same path to the point of projection. The velocity of third part of mass 2 m just after explosion will be

(1) $u\cos\theta$ (2) $\frac{3}{2}u\cos\theta$ (3) $2u\cos\theta$ (4) $\frac{5}{2}u\cos\theta$

Sol. Answer (4)



along x-axis no internal force exists, hence momentum will be conserved along x-axis

$$P_i)_x = P_f)_x$$

$$(m + m + 2m)\cos\theta = -mu\cos\theta + 0 + 2mV$$

$$\Rightarrow 2mv = 5\,mu\cos\theta$$

$$v = \frac{5}{2}u\cos\theta$$

and along y direction $P_i)_y = 0$ So $P_f)_y = 0$

19. A bomb of mass 9 kg explodes into two pieces of masses 3 kg and 6 kg. The velocity of mass 3 kg is 16 m/s. The kinetic energy of mass 6 kg in joule is

(1) 196 (2) 320 (3) 192 (4) 620

Sol. Answer (3)

Using momentum conservation

$$o = m_1v_1 + m_2v_2$$

$$V_2 = -\frac{3\times16}{6}$$

$$= -8 \text{ m/s}$$

$$\text{K.E.} = \frac{1}{2}mv^2 = \frac{1}{2}(6)(8)^2 = 192 \text{ J}$$

20. A 6000 kg rocket is set for firing. If the exhaust speed is 1000 m/s, how much gas must be ejected each second to supply the thrust needed to overcome the weight of the rocket?

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

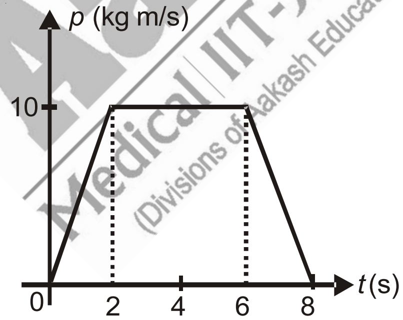
Sol. Answer (4)

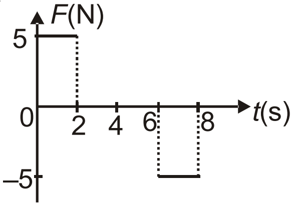
$$F = v\frac{dm}{dt} = \text{mg}$$

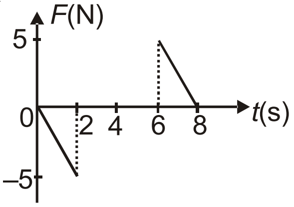
$$1000\left(\frac{dm}{dt}\right) = 60000$$

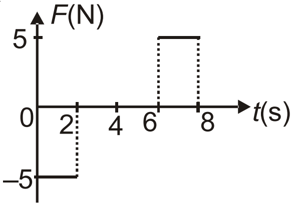
$$\frac{dm}{dt} = 60 \text{ kg}$$

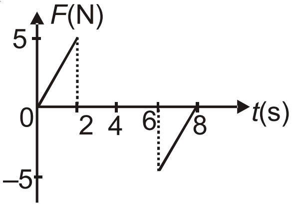
21. The momentum p of an object varies with time (t) as shown in figure. The corresponding force (F)-time (t) graph is



(1) 

(2) 

(3) 

(4) 

Sol. Answer (1)

$F = \frac{dp}{dt}$ = slope of P–t curve

From t = 0 to t = 2 second slope is constant and positive

From t = 2 to t = 6 second slope is zero

From t = 6 to t = 8 second slope is constant and negative

(Common Forces in Mechanics)

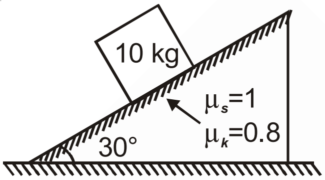
22. Which of the following is self adjusting force?

(1) Sliding friction (2) Dynamic friction (3) Static friction (4) Limiting friction

Sol. Answer (3)

Static friction

23. A block of 10 kg mass is placed on a rough inclined surface as shown in figure. The acceleration of the block will be



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

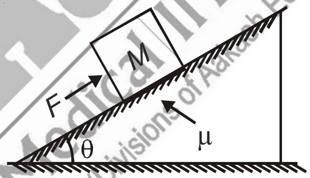
Sol. Answer (1)

$F_L = \mu_s mg\cos\theta = (1)(100)\frac{\sqrt{3}}{2} = 50\sqrt{3}$

Gravitational force = $mg\sin\theta$ = 50 N

$f_L > mg\sin\theta \Rightarrow$ block will not move

24. A block (mass = M kg) is placed on a rough inclined plane. A force F is applied parallel to the inclined (as shown in figure) such that it just starts moving upward. The value of F is



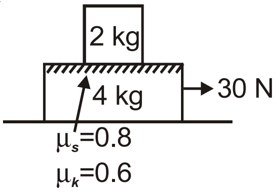
(1) $Mg\sin\theta - \mu Mg\cos\theta$ (2) $Mg\sin\theta + \mu Mg\cos\theta$ (3) $Mg\sin\theta$ (4) $\mu Mg\cos\theta$

Sol. Answer (2)

F will oppose friction force and gravitation force

$F = mg\sin\theta + \mu\, mg\cos\theta$

25. Figure shows two block system, 4 kg block rests on a smooth horizontal surface, upper surface of 4 kg is rough. A block of mass 2 kg is placed on its upper surface. The acceleration of upper block with respect to earth when 4 kg mass is pulled by a force of 30 N, is



(1) 6 m/s^2 (2) 5 m/s^2 (3) 8 m/s^2 (4) 2 m/s^2

Sol. Answer (2)

It both move together

$$a = \frac{30}{(4+2)} = 5 \text{ m/s}^2$$

2 kg will move due to frictional force

$F = ma \Rightarrow f = 2(5) = 10$ N

and limiting friction f_L = (0.8) (2g) = 16 N

$\Rightarrow$ Friction is sufficient to move both block together hence $a = 5$ m/s^2

26. A car accelerates on a horizontal road due to force exerted by

(1) The engine of the car

(2) The driver of the car

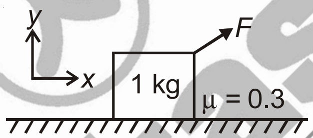
(3) The earth as weight of the car

(4) The road

Sol. Answer (4)

Due to frictional force by the road.

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



(1) $-\hat{i}$ (2) $-18\hat{i}$ (3) $-2.4\hat{i}$ (4) $-3\hat{i}$

Sol. Answer (1)

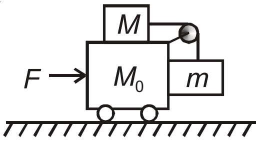
Limiting friction F_L = (0.3) (1) (g)

= 3 N

x-component or horizontal component of force is = 1 N

hence this much of magnitude will act in backward direction due to friction.

28. Two blocks of mass M and m are kept on the trolley whose all surfaces are smooth select the correct statement



(1) If F = 0 blocks cannot remain stationary

(2) For one unique value of F, blocks will be stationary

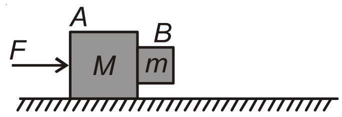
(3) Blocks cannot be stationary for any value of F because all surfaces are smooth

(4) Both (1) & (2)

Sol. Answer (4)

As all the surfaces are smooth, block can be at rest only due to Pseduo force

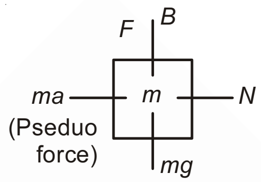
29. Coefficient of friction between A and B is μ. The minimum force F with which A will be pushed such that B will not slip down is



(1) $\frac{Mg}{\mu}$ (2) $\frac{mg}{\mu}$ (3) $\frac{(M+m)g}{\mu}$ (4) $\frac{(M-m)g}{\mu}$

Sol. Answer (3)

From the reference frame of A



$$\mu N = mg$$

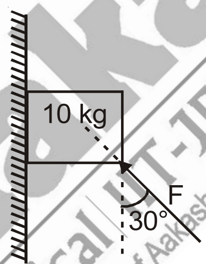
$$N = ma$$

$$N = m\left(\frac{F}{M+m}\right)$$

$$\mu m\left(\frac{F}{M+m}\right) = mg$$

$$F = \left(\frac{M+m}{\mu}\right) g$$

30. A block of mass 10 kg is held at rest against a rough vertical wall [μ = 0.5] under the action a force F as shown in figure. The minimum value of F required for it is (g = 10 m/s^2)



(1) 162.6 N (2) 89.7 N

(3) 42.7 N (4) 95.2 N

Sol. Answer (2)

$$N = F\sin 30° = F/2$$

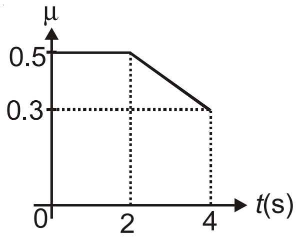
$$F\cos 30° + \mu N = (10)g$$

$$\frac{F\sqrt{3}}{2} + 0.5\left(\frac{F}{2}\right) = 100$$

$$F\left(\frac{2\sqrt{3}+1}{4}\right) = 100$$

$$F \simeq 89.7 \text{ N}$$

31. A block is projected with speed 20 m/s on a rough horizontal surface. The coefficient of friction (μ) between the surfaces varies with time (t) as shown in figure. The speed of body at the end of 4 second will be (g = 10 m/s^2)



(1) 2 m/s (2) 5 m/s (3) 7.2 m/s (4) 9.5 m/s

Sol. Answer (1)

Retardation

$$\frac{dv}{dt} = -\mu g$$

$$\int dv = -\int \mu g\, dt$$

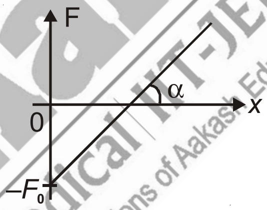
$$\Delta v = -g\int \mu\, dt$$

$\int \mu\, dt$ is area under $\mu - t$ curve

$$v - 20 = -10\left(2\,\frac{1}{2} + \frac{1}{2}(2)(0.2) + (2)(0.3)\right)$$

$$v = 20 - 18 = 2 \text{ m/s}$$

32. An object starts from rest and is acted upon by a variable force F as shown in figure. If F_0 is the initial value of the force, then the position of the object, where it again comes to rest will be



(1) $\dfrac{2F_0}{\tan\alpha}$ (2) $\dfrac{F_0}{\sin\alpha}$ (3) $\dfrac{2F_0}{\cot\alpha}$ (4) $\dfrac{F_0}{2\cos\alpha}$

Sol. Answer (1)

F-x curve is straight line. Equation of F in terms of x can be written as

$$F = x\tan\alpha - F_0$$

$$a = \frac{vdv}{dx} = \frac{F}{m} = \frac{x\tan\alpha}{m} - \frac{F_0}{m}$$

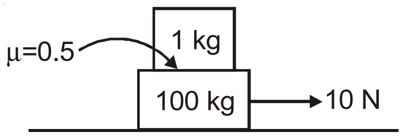
Integrating both sides

$$\frac{v^2 - x^2}{2} = \frac{x^2\tan\alpha}{2m} - \frac{F_0 x}{m} = 0$$

$$\frac{x\tan\alpha}{2} = F_0$$

$$x = \frac{2F_0}{\tan\alpha}$$

33. The frictional force acting on 1 kg block is



(Smooth surface)

(1) 0.1 N (2) 2 N (3) 0.5 N (4) 5 N

Sol. Answer (1)

If both move together $a = \dfrac{10}{101} \simeq 0.1$ m/s^2

Now, $F_{net} = 1\,(0.1) = 0.1$N

$f_L = (0.5)\,(1)\,(g) = 5$ N

So, $f = 0.1$N

34. A block of mass m is at rest on a rough inclined plane of angle of inclination θ. If coefficient of friction between the block and the inclined plane is μ, then the minimum value of force along the plane required to move the block on the plane is

(1) $mg[\mu\cos\theta - \sin\theta]$ (2) $mg[\sin\theta + \mu\cos\theta]$ (3) $mg[\mu\cos\theta + \sin\theta]$ (4) $mg[\sin\theta - \mu\cos\theta]$

Sol. Answer (1)

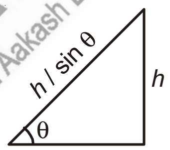
$F_{min} = mg[\mu\cos\theta - \sin\theta]$

35. A block of mass m takes time t to slide down on a smooth inclined plane of angle of inclination θ and height h. If same block slide down on a rough inclined plane of same angle of inclination and same height and takes time n times of initial value, then coefficient friction between block and inclined plane is

(1) $[1 + n^2]\tan\theta$ (2) $\left[1-\dfrac{1}{n^2}\right]\tan\theta$ (3) $[1 - n^2]\tan\theta$ (4) $\left[1+\dfrac{1}{n^2}\right]\tan\theta$

Sol. Answer (2)

$$t_1 = \sqrt{\frac{2}{g}\left(\frac{h}{\sin^2\theta}\right)} = \frac{1}{\sin\theta}\sqrt{\frac{2h}{g}}$$



$$t_2 = \sqrt{\frac{2h}{g\sin\theta(\sin\theta - \mu\cos\theta}}$$

According to problem

$$\frac{n}{\sin\theta}\sqrt{\frac{2h}{g}} = \sqrt{\frac{2h}{g\sin\theta(\sin\theta-\mu\cos\theta)}}$$

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

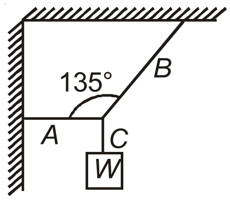
$n^2\sin^2\theta - n^2\mu\sin\theta\cos\theta = \sin^2\theta$

$$n^2\left[1-\frac{\mu}{\tan\theta}\right] = 1$$

$$\mu = \left[1-\frac{1}{n^2}\right]\tan\theta$$

(Equilibrium of a Particle Frame of Reference)

36. A block of weight W is supported by three strings as shown in figure. Which of the following relations is true for tension in the strings? (Here T_1, T_2 and T_3 are the tension in the strings A, B and C respectively)



(1) $T_1 = T_2$ (2) $T_1 = T_3$ (3) $T_2 = T_3$ (4) $T_1 = T_2 = T_3$

Sol. Answer (2)

Tension will be same in A & C hence $T_1 = T_3$

37. Which of the following quantity/quantities are dependent on the choice of orientation of the co-ordinate axes?

(a) $\vec{a}+\vec{b}$

(b) $3a_x + 2b_y$

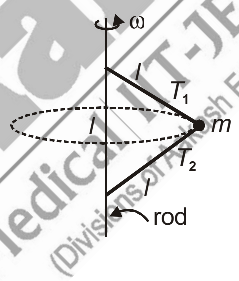
(c) $(\vec{a}+\vec{b}-\vec{c})$

(1) Only (b) (2) Both (a) & (b) (3) Both (a) & (c) (4) Both (b) & (c)

Sol. Answer (1)

(Circular Motion Solving Problems in Mechanics)

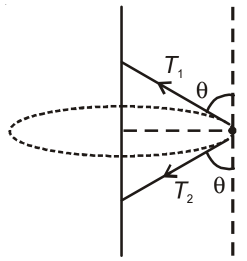
38. In the figure, a ball of mass m is tied with two strings of equal length as shown. If the rod is rotated with angular velocity ω, then



(1) $T_1 > T_2$ (2) $T_2 > T_1$

(3) $T_1 = T_2$ (4) $T_1 = \dfrac{T_2}{6}$

Sol. Answer (1)



For vertical equilibrium

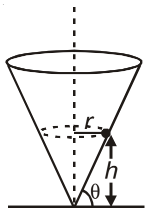
$T_1 \cos\theta = mg + T_2 \cos\theta$

$T_1 = \dfrac{mg}{\cos\theta} + T_2$

θ < 90° so cos θ > 0

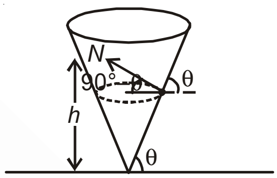
$\Rightarrow T_1 > T_2$

39. A particle describes a horizontal circle of radius r on the smooth surface of an inverted cone as shown. The height of plane of circle above vertex is h. The speed of particle should be



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

Sol. Answer (3)



$$N\cos(90° - \theta) = \frac{mv^2}{r}$$

$$N\sin(90° - \theta) = mg$$

$$N = \frac{mg}{\cos\theta} \quad \text{...(i)}$$

and $N\sin\theta = \dfrac{mv^2}{r}$ ...(ii)

dividing (ii) and (i)

$$mg\tan\theta = \frac{mv^2}{r}$$

$$g\left(\frac{h}{r}\right) = \frac{v^2}{r} \Rightarrow v = \sqrt{gh}$$

40. If the string of a conical pendulum makes an angle θ with horizontal, then square of its time period is proportional to

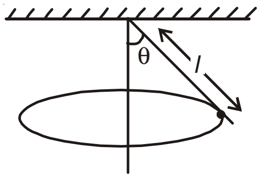
(1) sinθ (2) cosθ (3) tanθ (4) cotθ

Sol. Answer (1)

For conical pendulum we know that

$$T = 2\pi\sqrt{\frac{l\cos\theta}{g}}$$

where θ is the angle from vertical but in question θ is given from horizontal



hence $T = 2\pi\sqrt{\dfrac{l\sin\theta}{g}}$

$$T^2 \propto \sin\theta$$

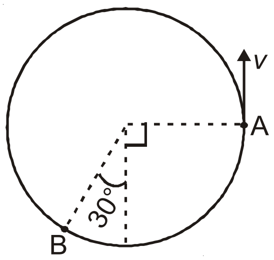
41. The acceleration vector of a particle in uniform circular motion averaged over the cycle is a null vector. This statement is

(1) True (2) False (3) May be true (4) May be false

Sol. Answer (1)

Acceleration will be towards centre at every instant.

42. A particle of mass *m* moves with constant speed *v* on a circular path of radius *r* as shown in figure. The average force on it during its motion from *A* to *B* is



(1) $\dfrac{\sqrt{3}mv^2}{2\pi r}$ (2) $\dfrac{mv^2}{r}$ (3) $\dfrac{2\sqrt{3}mv^2}{\pi r}$ (4) $\dfrac{3\sqrt{3}mv^2}{4\pi r}$

Sol. Answer (4)

$$F = ma = \frac{m\Delta v}{\Delta t} = \left[\frac{2v^2 \sin\theta/2}{r\theta}\right]$$

$$= m\left[\frac{2v^2 \sin(2\pi - 2\pi/3)}{r.\left(\frac{4\pi}{3}\right)}\right] = \frac{3\sqrt{3}\ mv^2}{4\pi r}$$

43. A person stands in contact against the inner wall of a rotor of radius *r*. The coefficient of friction between the wall and the clothing is μ and the rotor is rotating about vertical axis. The minimum angular speed of the rotor so that the person does not slip downward is

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

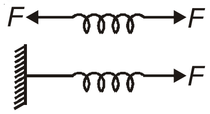
Sol. Answer (3)

$$N = \frac{mv^2}{r}$$

$$f_L = \mu N = \mu\left[\frac{mv^2}{r}\right] = mg$$

$$v = \sqrt{\frac{gr}{\mu}}$$

44. Figure shows two cases. In first case a spring (spring constant *K*) is pulled by two equal and opposite forces *F* at both ends and in second case is pulled by a force *F* at one end. Extensions (*x*) in the springs will be



(1) In both cases $x = \dfrac{2F}{K}$ (2) In both cases $x = \dfrac{F}{K}$

(3) In first case $x = \dfrac{2F}{K}$, in second case $x = \dfrac{F}{K}$ (4) In first case $x = \dfrac{F}{K}$, in second case $x = \dfrac{2F}{K}$

Sol. Answer (2)

Figure (2) is F.B.D. of figure (1)

at equilibrium $F = Kx$

$x = F/K$

SECTION - C

Previous Years Questions

1. One end of string of length l is connected to a particle of mass 'm' and the other end is connected to a small peg on a smooth horizontal table. If the particle moves in circle with speed 'v', the net force on the particle (directed towards center) will be (T represents the tension in the string) **[NEET-2017]**

(1) T (2) $T + \frac{mv^2}{l}$ (3) $T - \frac{mv^2}{l}$ (4) Zero

Sol. Answer (1)

Centripetal force $\left(\frac{mv^2}{l}\right)$ is provided by tension so the net force will be equal to tension *i.e.*, T.

2. Suppose the charge of a proton and an electron differ slightly. One of them is $-e$, the other is $(e + \Delta e)$. If the net of electrostatic force and gravitational force between two hydrogen atoms placed at a distance d (much greater than atomic size) apart is zero, then Δe is of the order of [Given mass of hydrogen $m_h = 1.67 \times 10^{-27}$ kg] **[NEET-2017]**

(1) 10^{-20} C (2) 10^{-23} C (3) 10^{-37} C (4) 10^{-47} C

Sol. Answer (3)

$F_e = F_g$

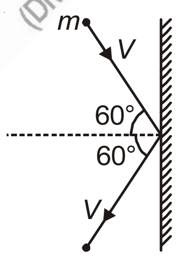
$$\frac{1}{4\pi\varepsilon_0}\frac{\Delta e^2}{d^2} = \frac{Gm^2}{d^2}$$

$9 \times 10^9 (\Delta e^2) = 6.67 \times 10^{-11} \times 1.67 \times 10^{-27} \times 1.67 \times 10^{-27}$

$$\Delta e^2 = \frac{6.67 \times 1.67 \times 1.67}{9} \times 10^{-74}$$

$$\Delta e \approx 10^{-37}$$

3. A rigid ball of mass m strikes a rigid wall at 60° and gets reflected without loss of speed as shown in the figure below. The value of impulse imparted by the wall on the ball will be **[NEET (Phase-2) 2016]**



(1) mV (2) $2mV$

(3) $\frac{mV}{2}$ (4) $\frac{mV}{3}$

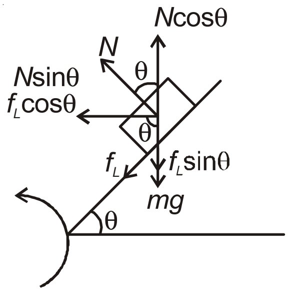
Sol. Answer (1)

$$|\vec{J}| = |\vec{P}_2 - \vec{P}_1| = 2mV\cos\theta = mV$$

4. A car is negotiating a curved road of radius R. The road is banked at an angle θ. The coefficient of friction between the tyres of the car and the road is μ_s. The maximum safe velocity on this road is **[NEET-2016]**

(1) $\sqrt{\dfrac{g}{R^2}\dfrac{\mu_s+\tan\theta}{1-\mu_s\tan\theta}}$ (2) $\sqrt{gR^2\dfrac{\mu_s+\tan\theta}{1-\mu_s\tan\theta}}$ (3) $\sqrt{gR\dfrac{\mu_s+\tan\theta}{1-\mu_s\tan\theta}}$ (4) $\sqrt{\dfrac{g}{R}\dfrac{\mu_s+\tan\theta}{1-\mu_s\tan\theta}}$

Sol. Answer (3)



Vertical equilibrium

$N\cos\theta = mg + f_L\sin\theta$

$\Rightarrow \; mg = N\cos\theta - f_L\sin\theta$ ...(1)

Horizontal equilirbium

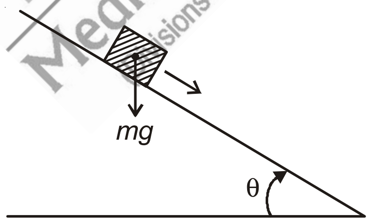
$N\sin\theta + f_L\cos\theta = \dfrac{mv^2}{R}$ ...(2)

$\dfrac{Eqn(2)}{Eqn(1)} \quad \dfrac{v^2}{Rg} = \dfrac{\sin\theta+\mu_s\cos\theta}{\cos\theta-\mu_s\sin\theta}$

$\Rightarrow \; v = \sqrt{Rg\dfrac{\sin\theta+\mu_s\cos\theta}{\cos\theta-\mu_s\sin\theta}}$

$= \sqrt{Rg\dfrac{\tan\theta+\mu_s}{1-\mu_s\tan\theta}}$

5. A plank with a box on it at one end is gradually raised about the other end. As the angle of inclination with the horizontal reaches 30º, the box starts to slip and slides 4.0 m down the plank in 4.0 s. The coefficients of static and kinetic friction between the box and the plank will be, respectively **[Re-AIPMT-2015]**



(1) 0.4 and 0.3 (2) 0.6 and 0.6 (3) 0.6 and 0.5 (4) 0.5 and 0.6

Sol. Answer (3)

Static coefficient of friction, $\mu_s = \tan 30°$

$\mu_s = \dfrac{1}{\sqrt{3}} = \dfrac{1}{1.7} \Rightarrow \mu_s = 0.6$

For kinetic friction, $a = \dfrac{2s}{t^2} = g\sin 30º - \mu_k\cos 30°$

$\mu_k = 0.5$

6. Two stones of masses m and 2 m are whirled in horizontal circles, the heavier one in a radius $\frac{r}{2}$ and lighter one in radius r. The tangential speed of lighter stone is n times that of the value of heavier stone when they experience same centripetal forces. The value of n is **[Re-AIPMT-2015]**

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

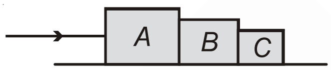
Sol. Answer (2)

$$F = \frac{m(nv)^2}{r} = \frac{2mv^2}{\frac{r}{2}}$$

$n^2 = 4$

$n = 2$

7. Three blocks A, B and C of masses 4 kg, 2 kg and 1 kg respectively, are in contact on a frictionless surface, as shown. If a force of 14 N is applied on the 4 kg block, then the contact force between A and B is **[AIPMT-2015]**



(1) 18 N (2) 2 N

(3) 6 N (4) 8 N

Sol. Answer (3)

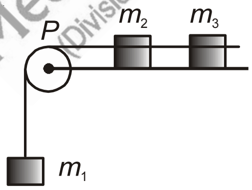
8. A block A of mass m_1 rests on a horizontal table. A light string connected to it passes over a frictionless pulley at the edge of table and from its other end another block B of mass m_2 is suspended. The coefficient of kinetic friction between the block and table is μ_k. When the block A is sliding on the table, the tension in the string is **[AIPMT-2015]**

(1) $\dfrac{m_1 m_2 (1-\mu_k)g}{(m_1+m_2)}$ (2) $\dfrac{(m_2+\mu_k m_1)g}{(m_1+m_2)}$

(3) $\dfrac{(m_2-\mu_k m_1)g}{(m_1+m_2)}$ (4) $\dfrac{m_1 m_2 (1+\mu_k)g}{(m_1+m_2)}$

Sol. Answer (4)

9. A system consists of three masses m_1, m_2 and m_3 connected by a string passig over a pulley P. The mass m_1 hangs freely and m_2 and m_3 are on a rough horizontal table (The coefficient of friction $= \mu$). The pulley is frictionless and of negligible mass. The downward acceleration of mass m_1 is: (Assume $m_1 = m_2 = m_3 = m$) **[AIPMT-2014]**



(1) $\dfrac{g(1-g\mu)}{9}$ (2) $\dfrac{2g\mu}{3}$

(3) $\dfrac{g(1-2\mu)}{3}$ (4) $\dfrac{g(1-2\mu)}{2}$

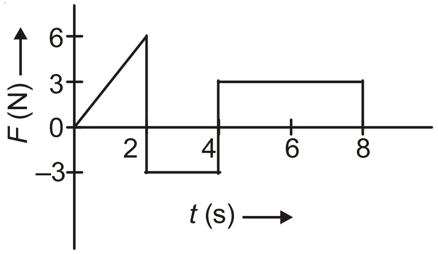
Sol. Answer (3)

$m_1 g - T = m_1 a$ ...(i)

$T - \mu(m_2 + m_3)g = (m_2 + m_3)a$ ...(ii)

Solve (i) & (ii) for a

10. The force F acting on a particle of mass m is indicated by the force-time graph shown below. The change in momentum of the particle over the time interval from 0 s to 8 s is **[AIPMT-2014]**



(1) 24 Ns (2) 20 Ns

(3) 12 Ns (4) 6 Ns

Sol. Answer (3)

$\Delta P = \int_0^8 F dt$

So area of $F - t$ curve will give change in momentum.

$\Delta P = \frac{1}{2} \times 2 \times 6 - (2 \times 3) + 4 \times 3 = 12$ Ns

11. A balloon with m is descending down with an acceleration a (where $a < g$). How much mass should be removed from it so that it starts moving up with an acceleration a? **[AIPMT-2014]**

(1) $\frac{2ma}{g+a}$ (2) $\frac{2ma}{g-a}$ (3) $\frac{ma}{g+a}$ (4) $\frac{ma}{g-a}$

Sol. Answer (1)

12. The upper half of an inclined plane of inclination θ is perfectly smooth while lower half is rough. A block starting from rest at the top of the plane will again come to rest at the bottom, if the coefficient of friction between the block and lower half of the plane is given by **[NEET-2013]**

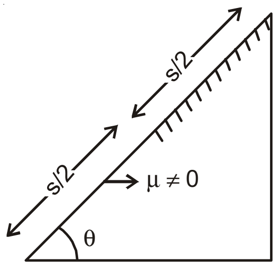
(1) $\mu = \frac{2}{\tan\theta}$ (2) $\mu = 2\tan\theta$

(3) $\mu = \tan\theta$ (4) $\mu = \frac{1}{\tan\theta}$

Sol. Answer (2)

For first half

$v = \sqrt{2g\sin\theta\left(\frac{s}{2}\right)} = \sqrt{sg\sin\theta}$



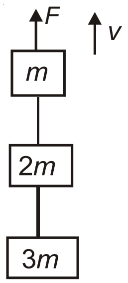
for second half

$\frac{s}{2} = \frac{sg\sin\theta}{2\,(g\sin\theta - \mu g\cos\theta)}$

Solving this

$\mu = 2\tan\theta$

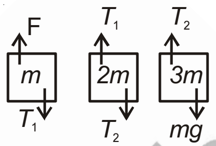
13. Three blocks with masses m, $2m$ and $3m$ are connected by strings, as shown in the figure. After an upward force F is applied on block m, the masses move upward at constant speed v. What is the net force on the block of mass $2m$? (g is the acceleration due to gravity) **[NEET-2013]**



(1) $2mg$ (2) $3mg$ (3) $6mg$ (4) Zero

Sol. Answer (4)

$a = 0$



Using $F_{net} = M_{total}a$

$F - (m + 2m + 3m) = 0$

$F = 6\ m$

$T_1 = F$, $T_2 = T_1$ since $a = 0$

Hence net force on $2m$ will be $T_1 - T_2 = 0$

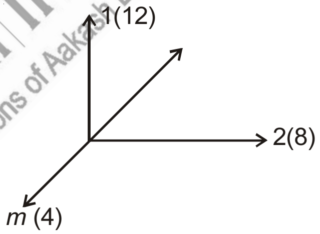
14. An explosion breaks a rock into three parts in a horizontal plane. Two of them go off at right angles to each other. the first part of mass 1 kg moves with a speed of 12 ms^{-1} and the second part of mass 2 kg moves with 8 ms^{-1} speed. If the third part flies off with 4 ms^{-1} speed, then its mass is **[NEET-2013]**

(1) 5 kg (2) 7 kg

(3) 17 kg (4) 3 kg

Sol. Answer (1)

Using momentum conservation



$m(4) = \sqrt{(12)^2 + (16)^2}$

$4m = 20$

$m = 5$ kg

15. A car of mass 1000 kg negotiates a banked curve of radius 90 m on a frictionless road. If the banking angle is 45°, the speed of the car is **[AIPMT (Prelims)-2012]**

(1) 5 ms^{-1} (2) 10 ms^{-1}

(3) 20 ms^{-1} (4) 30 ms^{-1}

Sol. Answer (4)

$\tan\theta = \dfrac{v^2}{rg}$

$\tan 45° = \dfrac{v^2}{90(10)}$

$v = 30$ m/s

16. A car of mass m is moving on a level circular track of radius R. If μ_s represents the static friction between the road and tyres of the car, the maximum speed of the car in circular motion is given by

[AIPMT (Mains)-2012]

(1) $\sqrt{\mu_s mRg}$ (2) $\sqrt{\frac{Rg}{\mu_s}}$ (3) $\sqrt{\frac{mRg}{\mu_s}}$ (4) $\sqrt{\mu_s Rg}$

Sol. Answer (4)

$$\tan\theta = \mu_s = \frac{v^2}{Rg}$$

$$\Rightarrow v_{max.} = \sqrt{\mu_s Rg}$$

17. A person of mass 60 kg is inside a lift of mass 940 kg and presses the button on control panel. The lift starts moving upwards with an acceleration 1 m/s^2. If g = 10 ms^{-2}, the tension in the supporting cable is

[AIPMT (Prelims)-2011]

(1) 1200 N (2) 8600 N (3) 9680 N (4) 11000 N

Sol. Answer (4)

$T = mg + ma$

$= m(g + a)$

$= 1000 (10 + 1) = 11000$ N

18. A body of mass M hits normally a rigid wall with velocity v and bounces back with the same velocity. The impulse experienced by the body is **[AIPMT (Prelims)-2011]**

(1) Zero (2) Mv (3) $1.5Mv$ (4) $2Mv$

Sol. Answer (4)

Impulse = change in momentum

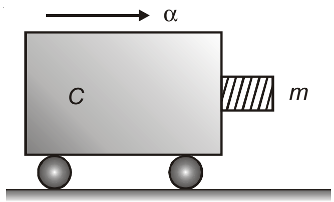
$= Mv - (-Mv) = 2Mv$

19. A radioactive nucleus of mass M emits a photon of frequency ν and the nucleus recoils. The recoil energy will be: **[AIPMT (Prelims)-2011]**

(1) $h\nu$ (2) $Mc^2 - h\nu$ (3) $\frac{h^2\nu^2}{2Mc^2}$ (4) Zero

Sol. Answer (3)

20. A block of mass m is in contact with the cart C as shown in the figure.



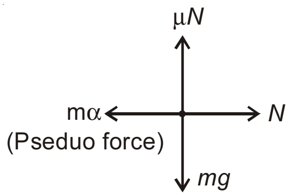
The coefficient of static friction between the block and the cart is μ. The acceleration α of the cart that will prevent the block from falling satisfies: **[AIPMT (Prelims)-2010]**

(1) $\alpha > \frac{mg}{\mu}$ (2) $\alpha > \frac{g}{\mu m}$ (3) $\alpha \geq \frac{g}{\mu}$ (4) $\alpha < \frac{g}{\mu}$

Sol. Answer (3)

$\Rightarrow \quad mg \leq \mu(m\alpha)$

$\alpha \geq \dfrac{g}{\mu}$



21. A gramophone record is revolving with an angular velocity ω. A coin is placed at a distance r from the centre of the record. The static coefficient of friction is μ. The coin will revolve with the record if: **[AIPMT (Prelims)-2010]**

(1) $r = \mu g \omega^2$ (2) $r < \dfrac{\omega^2}{\mu g}$ (3) $r < \dfrac{\mu g}{\omega^2}$ (4) $r \geq \dfrac{\mu g}{\omega^2}$

Sol. Answer (3)

22. A body, under the action of a force $\vec{F} = 6\hat{i} - 8\hat{j} + 10\hat{k}$, acquires an acceleration of 1 m/s^2. The mass of this body must be: **[AIPMT (Prelims)-2009]**

(1) 10 kg (2) 20 kg (3) $10\sqrt{2}$ kg (4) $2\sqrt{10}$ kg

Sol. Answer (3)

23. The mass of a lift is 2000 kg. When the tension in the supporting cable is 28000 N, then its acceleration is: **[AIPMT (Prelims)-2009]**

(1) 4 ms^{-2} upwards (2) 4 ms^{-2} downwards (3) 14 ms^{-2} upwards (4) 30 ms^{-2} downwards

Sol. Answer (1)

$F_{net} = ma$

$28000 - 2000\,g = 2000\,a$

$\Rightarrow a = \dfrac{8000}{2000} = 4$ m/s^2 upwards

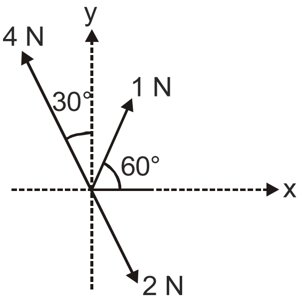
24. Sand is being dropped on a conveyor belt at the rate of M kg/s. The force necessary to keep the belt moving with a constant velocity of v m/s will be **[AIPMT (Prelims)-2008]**

(1) Zero (2) Mv newton (3) $2Mv$ newton (4) $\dfrac{Mv}{2}$ newton

Sol. Answer (2)

$F = \dfrac{vdM}{dt} = vM$

25. Three forces acting on a body are shown in the figure. To have the resultant force only along the y-direction, the magnitude of the minimum additional force needed is **[AIPMT (Prelims)-2008]**



(1) $\sqrt{3}$ N (2) 0.5 N (3) 1.5 N (4) $\dfrac{\sqrt{3}}{4}$ N

Sol. Answer (2)

To have the resultant force only along the *y*-direction

$\Rightarrow$ Component of forces along *x*-axis should be zero

$4 \sin 30° - 1 \cos 60° - 2 \cos 60° = x$

$x = 0.5$ N

26. A roller coaster is designed such that riders experience "weightlessness" as they go round the top of a hill whose radius of curvature is 20 m. The speed of the car at the top of the hill is between

[AIPMT (Prelims)-2008]

(1) 13 m/s and 14 m/s (2) 14 m/s and 15 m/s (3) 15 m/s and 16 m/s (4) 16 m/s and 17 m/s

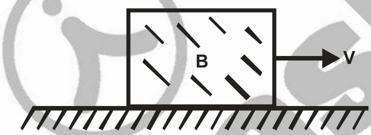
Sol. Answer (2)

$$\frac{mv^2}{r} = mg$$

$$\Rightarrow v = \sqrt{20 \times 10}$$

$$= 10\sqrt{2} \cong 14.1 \text{ m/s}$$

27. A block *B* is pushed momentarily along a horizontal surface with an initial velocity *v*. If μ is the coefficient of sliding friction between *B* and the surface, block *B* will come to rest after a time **[AIPMT (Prelims)-2007]**



(1) $\frac{v^2}{g\mu}$ (2) $\frac{v}{\mu g}$ (3) $\frac{g\mu}{v}$ (4) $\frac{g}{v}$

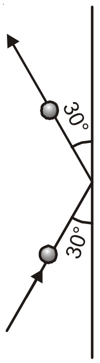
Sol. Answer (2)

$v = u - at$

$v = 0$

$t = \frac{v}{\mu g}$

28. A 0.5 kg ball moving with a speed of 12 m/s strikes a hard wall at an angle of 30° with the wall. It is reflected with the same speed and at the same angle. If the ball is in contact with the wall for 0.25 s, the average force acting on the wall is: **[AIPMT (Prelims)-2006]**



(1) 48 N (2) 24 N (3) 12 N (4) 96 N

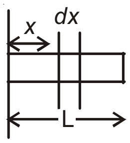
Sol. Answer (2)

29. A tube of length L is filled completely with an incompressible liquid of mass M and closed at both the ends. The tube is then rotated in a horizontal plane about one of its ends with a uniform angular velocity ω. The force exerted by the liquid at the other end is : **[AIPMT (Prelims)-2006]**

(1) $\dfrac{ML\omega^2}{2}$ (2) $\dfrac{ML^2\omega}{2}$

(3) $ML\omega^2$ (4) $\dfrac{ML^2\omega^2}{2}$

Sol. Answer (1)



$$dm = \frac{M}{L}dx$$

$$\int dF = \int_0^L dM\,\omega^2 x \qquad [\because F = M\omega^2 r]$$

$$F = \frac{M\omega^2}{L}\int_0^L x\,dx$$

$$= \frac{M\omega^2}{L}\left(\frac{L^2}{2}\right)$$

$$= \frac{M\omega^2 L}{2}$$

30. A conveyor belt is moving at a constant speed of 2 m/s. A box is gently dropped on it. The coefficient of friction between them is $\mu = 0.5$. The distance that the box will move relative to belt before coming to rest on it, taking $g = 10\ \text{ms}^{-2}$, is **[AIPMT (Mains)-2011]**

(1) Zero (2) 0.4 m (3) 1.2 m (4) 0.6 m

Sol. Answer (2)

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

$(2)^2 - 0 = 2\,(0.5 \times 10)s$

$\Rightarrow\ s = \dfrac{4}{10} = 0.4$ m

31. A stone is dropped from a height h. It hits the ground with a certain momentum P. If the same stone is dropped from a height 100% more than the previous height, the momentum when it hits the ground will change by

(1) 68% (2) 41%

(3) 200% (4) 100%

Sol. Answer (2)

$$\frac{h'-h}{h}\times 100 = 100 \Rightarrow h' = 2h$$

$$mv_1 = m\sqrt{2gh}$$

$$mv_2 = m\sqrt{2g(2h)} = \sqrt{2}\,mv_1$$

$$\text{change\%} = \frac{\sqrt{2}\,mv_1 - mv_1}{mv_1}\times 100 = 41\%$$

32. A mass m moving horizontally (along the x-axis) with velocity v collides and sticks to a mass of $3m$ moving vertically upward (along the y-axis) with velocity $2v$. The final velocity of the combination is

(1) $\frac{2}{3}v\hat{i}+\frac{1}{3}v\hat{j}$ (2) $\frac{3}{2}v\hat{i}+\frac{1}{4}v\hat{j}$ (3) $\frac{1}{4}v\hat{i}+\frac{3}{2}v\hat{j}$ (4) $\frac{1}{3}v\hat{i}+\frac{2}{3}v\hat{j}$

Sol. Answer (3)

Using momentum conservation, $mv\hat{i}+3m(2v)\hat{j} = 4m\vec{v}$

$$\vec{v} = \frac{1}{4}v\hat{i}+\frac{3}{2}v\hat{j}$$

33. An object is moving on a plane surface uniform velocity 10 ms^{-1} in presence of a force 10 N. The frictional force between the object and the surface is

(1) 1 N (2) –10 N (3) 10 N (4) 100 N

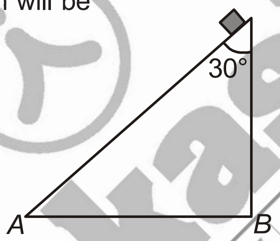
Sol. Answer (2)

F_{net} = 0 to move with constant velocity

$F + F = 0$

$F = -10$ N

34. A body of mass M starts sliding down on the inclined plane where the critical angle is $\angle ACB = 30°$ as shown in figure. The coefficient of kinetic friction will be



(1) $\frac{Mg}{\sqrt{3}}$ (2) $\sqrt{3}Mg$ (3) $\sqrt{3}$ (4) None of these

Sol. Answer (3)

$mg\sin\theta = \mu mg\cos\theta$

where $\theta = 90 - 30° = 60°$

$\tan\theta = \mu$

$\mu = \sqrt{3}$

35. In non-inertial frame, the second law of motion is written as

(1) $F = ma$ (2) $F = ma + F_p$ (3) $F = ma - F_p$ (4) $F = 2ma$

where F_p is a pseudo-force while a is the acceleration of the body relative to non-inertial frame.

Sol. Answer (3)

$F = ma - F_p$

where F_p is pseudo force

36. A person holding a rifle (mass of person and rifle together is 100 kg) stands on a smooth surface and fires 10 shots horizontally, in 5 s. Each bullet has a mass of 10 g with a muzzle velocity of 800 ms^{-1}. The final velocity acquired by the person and the average force exerted on the person are

(1) –1.6 ms^{-1}; 8 N (2) –0.08 ms^{-1}; 16 N

(3) –0.8 ms^{-1}; 16 N (4) –1.6 ms^{-1}; 16 N

Sol. Answer (3)

Bullet shots per second = $\frac{10}{5} = 2$

Using momentum conservation

$$0 = 10 \times \frac{10}{1000}(800) + 100\ V \Rightarrow V = -0.8 \text{ m/s}$$

$$F = n\ mV$$

$$= 2 \times \frac{(10)}{1000} \times 800 = 16 \text{ N}$$

37. In a rocket, fuel burns at the rate of 1 kg/s. This fuel is ejected from the rocket with a velocity of 60 km/s. This exerts a force on the rocket equal to

(1) 6000 N (2) 60000 N (3) 60 N (4) 600 N

Sol. Answer (2)

$$F = \frac{vdm}{dt}$$

$$= 60 \times 10^3 \times (1)$$

$$= 60000 \text{ N}$$

38. A satellite in force-free space sweeps stationary interplanetary dust at a rate of $dM/dt = \alpha v$, where M is mass and v is the speed of satellite and α is a constant. The tangential acceleration of satellite is

(1) $\frac{-\alpha v^2}{2M}$ (2) $-\alpha v^2$ (3) $\frac{-2\alpha v^2}{M}$ (4) $\frac{-\alpha v^2}{M}$

Sol. Answer (4)

$$a = \frac{F}{M} = \frac{-\alpha\ v.v}{M} = \frac{-\alpha\ v^2}{M}$$

39. A man fires a bullet of mass 200 gm at a speed of 5 m/s. The gun is of one kg mass. By what velocity the gun rebounds backward?

(1) 1 m/s (2) 0.01 m/s (3) 0.1 m/s (4) 10 m/s

Sol. Answer (1)

Using momentum conservation

$$v = \frac{(0.2)5}{1} = 1 \text{ m/s}$$

40. A 10 N force is applied on a body produces in it an acceleration of 1 m/s^2. The mass of the body is

(1) 15 kg (2) 20 kg (3) 10 kg (4) 5 kg

Sol. Answer (3)

$$m = \frac{F}{a} = \frac{10}{1} = 10 \text{ kg}$$

41. A force of 6 N acts on a body at rest and of mass 1 kg. During this time, the body attains a velocity of 30 m/s. The time for which the force acts on the body is

(1) 7 second (2) 5 second (3) 10 second (4) 8 second

Sol. Answer (2)

$$a = \frac{6}{1} = 6 \text{ m/s}^2$$

$$v = at$$

$$\Rightarrow t = \frac{v}{a} = \frac{30}{6} = 5 \text{ s}$$

42. A shell, in flight, explodes into four unequal parts. Which of the following is conserved?

(1) Potential energy (2) Momentum (3) Kinetic energy (4) Both (1) & (3)

Sol. Answer (2)

43. A 5000 kg rocket is set for vertical firing. The exhaust speed is 800 ms^{-1}. To give an initial upward acceleration of 20 ms^{-2}, the amount of gas ejected per second to supply the needed thrust will be (g = 10 ms^{-2})

(1) 185.5 kg s^{-1} (2) 187.5 kg s^{-1} (3) 127.5 kg s^{-1} (4) 137.5 kg s^{-1}

Sol. Answer (2)

m = 5000 kg v = 800 m/s a = 20 m/s^2

$$a = \frac{v\frac{dm}{dt} - mg}{m} = \frac{800\left(\frac{dm}{dt}\right) - 50000}{5000} = 2$$

$$\Rightarrow \frac{dm}{dt} = 187.5 \text{ kg/s}$$

44. A bullet is fired from a gun. The force on the bullet is given by $F = 600 - 2 \times 10^5\, t$, where F is in newton and t in second. The force on the bullet becomes zero as soon as it leaves the barrel. What is the impulse imparted to the bullet?

(1) 9 Ns (2) Zero (3) 1.8 Ns (4) 0.9 Ns

Sol. Answer (4)

When bullet leaves the barrel, force becomes zero

$$F = 600 - 2 \times 10^5 t = 0$$

$$t = \frac{600}{2\times10^5} = 3 \times 10^{-3} \text{ s}$$

$$I = \int F dt = \int_0^{3\times10^{-3}} (600 - 2\times10^5 t)\ dt$$

$$\left[600t - 2\times\frac{10^5 t^2}{2}\right]_0^{3\times10^{-3}} = 1.8 - 0.9 = 0.9 \text{ N.s}$$

45. A ball of mass 0.25 kg attached to the end of a string of length 1.96 m is moving in a horizontal circle. The string will break if the tension is more than 25 N. What is the maximum speed with which the ball can be moved?

(1) 5 m/s (2) 3 m/s (3) 14 m/s (4) 3.92 m/s

Sol. Answer (3)

$$T_{max.} = 25 = \frac{mv_{max.}^2}{R}$$

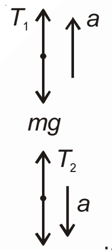
$$v_{max.}^2 = 196$$

$$v_{max.} = 14 \text{ m/s}$$

46. A mass of 1 kg is suspended by a thread. It is (i) lifted up with an acceleration 4.9 m/s^2, (ii) lowered with an acceleration 4.9 m/s^2. The ratio of the tensions is

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

Sol. Answer (3)



$$T_1 = mg + ma$$

$$T_2 = mg - ma$$

$$\frac{T_1}{T_2} = \frac{9.8+4.9}{9.8-4.9} = \frac{3}{1}$$

47. If the force on a rocket, that releases the exhaust gases with a velocity of 300 m/s is 210 N, then the rate of combustion of the fuel is

(1) 0.07 kg/s (2) 1.4 kg/s (3) 0.7 kg/s (4) 10.7 kg/s

Sol. Answer (3)

$$F = \frac{vdm}{dt}$$

$$\frac{dm}{dt} = \frac{F}{v} = \frac{210}{300} = 0.7 \text{ kg/s}$$

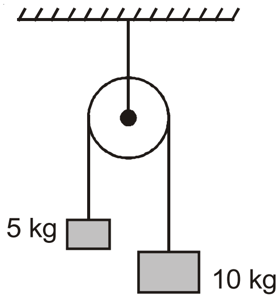
48. A 500 kg car takes a round turn of radius 50 m with a velocity of 36 km/h. The centripetal force is

(1) 1000 N (2) 750 N (3) 250 N (4) 1200 N

Sol. Answer (1)

$$F_c = \frac{mv^2}{r} = \frac{500(10)^2}{50} = 1000 \text{ N}$$

49. Two masses as shown are suspended from a massless pulley. Calculate the acceleration of the 10 kg mass when masses are left free



(1) $\frac{2g}{3}$ (2) $\frac{g}{3}$ (3) $\frac{g}{9}$ (4) $\frac{g}{7}$

Sol. Answer (2)

$$a = \left(\frac{m_1 - m_2}{m_1 + m_2}\right) g = \frac{g}{3}$$

50. A mass of 1 kg is thrown up with a velocity of 100 m/s. After 5 second, it explodes into two parts. One part of mass 400 g moves down with a velocity 25 m/s. Calculate the velocity of other part just after the explosion. (g = 10 ms^{-2})

(1) 40 m/s ↑ (2) 40 m/s ↓ (3) 100 m/s ↑ (4) 60 m/s ↑

Sol. Answer (3)

$$v = u - g(t) = 50 \text{ m/s}$$

$$\text{So, } 1\,(50) = \frac{400}{1000}\,(25) + \frac{600}{1000}v$$

$$v = 100 \text{ m/s} \uparrow$$

51. A man is slipping on a frictionless inclined plane and a bag falls down from the same height. Then the velocity of both is related as (V_B = velocity of bag and V_m = velocity of man)

(1) $V_B > V_m$ (2) $V_B < V_m$

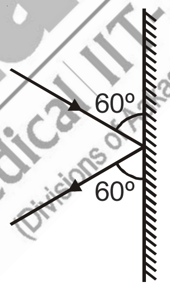
(3) $V_B = V_m$ (4) V_B and V_m can't be related

Sol. Answer (3)

Height is same and friction is absent so using mechanical energy conservation both will reach with the same speed.

$$mgh = \frac{1}{2}mv^2$$

52. A body of mass 3 kg moving with velocity 10 m/s hits a wall at an angle of 60° and returns at the same angle. The impact time was 0.2 s. Calculate the force exerted on the wall.



(1) $150\sqrt{3}$ N (2) $50\sqrt{3}$ N (3) 100 N (4) 75 N

Sol. Answer (1)

$$F = \frac{\Delta p}{\Delta t} = \frac{2(3)(10)\sin 60^\circ}{0.2} = 300\frac{\sqrt{3}}{2} = 150\sqrt{3} \text{ N}$$

53. A cricketer catches a ball of mass 150 g in 0.1 s moving with speed 20 m/s, then he experiences force of

(1) 300 N (2) 30 N (3) 3 N (4) 0.3 N

Sol. Answer (2)

$$F = \frac{\Delta p}{\Delta t} = \frac{0 - \frac{150}{1000}(20)}{0.1} = 30 \text{ N}$$

54. On the horizontal surface of a truck, a block of mass 1 kg is placed (μ = 0.6) and truck is moving with acceleration 5 m/s^2 then the frictional force on the block will be

(1) 5 N (2) 6 N (3) 5.88 N (4) 8 N

Sol. Answer (1)

$f_L = 0.6 \times 1\ g = 6$ N

Now, $F_{net} = 1\ (5) = 5$ N

$\Rightarrow$ Only static friction is acting on it.

55. An object of mass 3 kg is at rest. Now a force $\vec{F} = 6t^2\hat{i} + 4t\hat{j}$ is applied on the object then velocity of object at t = 3s is

(1) $18\hat{i} + 3\hat{j}$ (2) $18\hat{i} + 6\hat{j}$

(3) $3\hat{i} + 18\hat{j}$ (4) $18\hat{i} + 4\hat{j}$

Sol. Answer (2)

$\vec{F} = 6t^2\hat{i} + 4t\hat{j}$

$\frac{mdv}{dt} = 6t^2\hat{i} + 4\hat{t}\ \hat{j}$

$mdv = 6t^2\ dt\hat{i} + 4tdt.\ \hat{j}$

Integrating both sides

$m(v-u) = \left[2t^3\hat{i} + 2t^2\hat{j}\right]_{t=0}^{t=3}$

given $u = 0$, $m = 3$ kg

$v = 18\hat{i} + 6\hat{j}$

56. A block of mass 10 kg placed on rough horizontal surface having coefficient of friction μ = 0.5, if a horizontal force of 100 N is acting on it then acceleration of the block will be (g = 10 ms^{-2})

(1) 10 m/s^2 (2) 5 m/s^2 (3) 15 m/s^2 (4) 0.5 m/s^2

Sol. Answer (2)

$a = \frac{F - f_k}{m} = \frac{100 - (0.5)(10)\ (10)}{10} = \frac{50}{10} = 5$ m/s^2

57. A lift of mass 1000 kg is moving with acceleration of 1 m/s^2 in upward direction, then the tension developed in string which is connected to lift is

(1) 9800 N (2) 10,800 N

(3) 11,000 N (4) 10,000 N

Sol. Answer (2)

$T = m(g + a)$

$= 1000\ (9.8 + 1)$

$= 10800$ N

58. A monkey of mass 20 kg is holding a vertical rope. The rope will not break when a mass of 25 kg is suspended from it but will break if the mass exceeds 25 kg. What is the maximum acceleration with which the monkey can climb up along the rope? (g = 10 m/s^2)

(1) 5 m/s^2 (2) 10 m/s^2 (3) 25 m/s^2 (4) 2.5 m/s^2

Sol. Answer (4)

$T_{max.} - mg = ma$

$250 - 20g = 20a$

$a = 2.5$ m/s^2

59. A man weighs 80 kg. He stands on a weighing scale in a lift which is moving upwards with a uniform acceleration of 5 m/s^2. What would be the reading on the scale? (g = 10 m/s^2)

(1) Zero (2) 400 N (3) 800 N (4) 1200 N

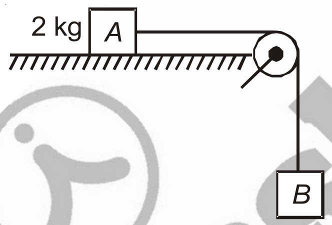
Sol. Answer (4)

$W_{app} = m(g + a)$

$= 80\ (10 + 5)$

$= 1200$ N

60. The coefficient of static function, (μ_s) between block A of mass 2 kg and the table as shown in the figure is 0.2. What would be the maximum mass value of block B so that the two blocks do not move? (The string and the pulley are assumed to be smooth and massless)



(1) 2.0 kg (2) 4.0 kg

(3) 0.2 kg (4) 0.4 kg

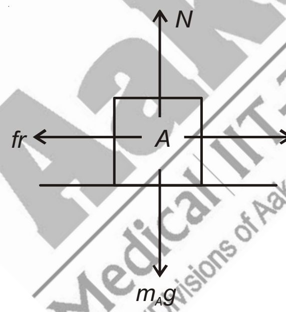
Sol. Answer (4)

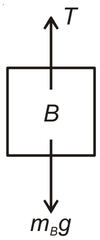
$T < fr$

$M_B g < \mu_S\ (2)\ (g)$

$M_B < (0.2)\ (g)$

$M_B < 0.4$ kg





61. A block of mass m is placed on a smooth wedge of inclination θ. The whole system is accelerated horizontally so that the block does not slip on the wedge. The force exerted by the wedge on the block (g is acceleration due to gravity) will be

(1) $mg\cos\theta$ (2) $mg\sin\theta$

(3) mg (4) $mg/\cos\theta$

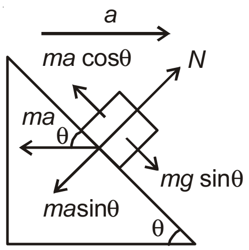
Sol. Answer (4)

$mg\sin\theta = ma\cos\theta$

$\Rightarrow a = g\tan\theta$

$N = ma\sin\theta + mg\cos\theta$

$$N = \frac{mg\sin^2\theta}{\cos\theta} + mg\cos\theta = \frac{mg}{\cos\theta}$$

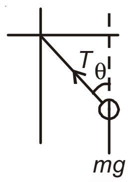


62. A car is moving in a circular horizontal track of radius 10 m with a constant speed of 10 m/s. A bob is suspended from the roof of the car by a light wire of length 1.0 m. The angle made by the wire with the vertical is

(1) 0° (2) $\frac{\pi}{3}$

(3) $\frac{\pi}{6}$ (4) $\frac{\pi}{4}$

Sol. Answer (4)



$T \cos \theta = mg$

$T \sin \theta = \frac{mv^2}{r}$

Divide both equations, $\tan \theta = \frac{v^2}{rg} = \frac{10\times10}{10\times10} \Rightarrow \theta = 45°$

63. A man of 50 kg mass is standing in a gravity free space at a height of 10 m above the floor. He throws a stone of 0.5 kg mass downwards with a speed 2 m/s. When the stone reaches the floor, the distance of the man above the floor will be

(1) 20 m (2) 9.9 m (3) 10.1 m (4) 10 m

Sol. Answer (3)

Using momentum conservation, $0 = 0.5\ (2) + 50\ V \Rightarrow V = \frac{1}{50}$ m/s

Time taken by stone to reach the ground

$S = ut$

$10 = 2(t) \Rightarrow t = 5$ second

Distance covered by man upwards will be $S = \left(\frac{1}{50}\right)5 = 0.1$ m

Total height above the ground = 10 + 0.1 = 10.1 m

SECTION - D

Assertion-Reason Type Questions

1. A : Due to inertia an object is unable to change by itself its state of rest and uniform motion.
   R : An object cannot change its state unless acted upon by an unbalanced external force.

Sol. Answer (1)

2. A : Acceleration of an object in uniform motion is zero.
   R : No force is required to move an object uniformly

Sol. Answer (1)

3. A : Newton's second law of motion gives the measurement of force.
   R : According to second law of motion, force is directly proportional to the rate of change of momentum.

Sol. Answer (1)

4. A : According to Newton's third law of motion for every action, there is an equal and opposite reaction.

R : There is no time lag between action and reaction.

Sol. Answer (2)

5. A : Inertia depends on the mass of an object.

R : Greater the mass, larger is the force required to change its state of rest or of uniform motion.

Sol. Answer (1)

6. A : In case of free fall of a lift, the apparent weight of a man in it will be zero.

R : In free fall, acceleration of lift is equal to acceleration due to gravity.

Sol. Answer (1)

7. A : Static friction force is a self adjusting force.

R : The interatomic forces at the point of contact give rise to friction between the surfaces.

Sol. Answer (2)

8. A : The value of kinetic friction is less than the limiting friction.

R : When motion of an object started, the inertia of rest has been overcome.

Sol. Answer (1)

9. A : During horizontal circular turn of a car, the centripetal force required should be less than the limiting friction between its tyres and road.

R : The centripetal force to car is provided by the frictional force between its tyres and the road.

Sol. Answer (1)

10. A : A person on a frictionless surface can get away from it by blowing air out of his mouth.

R : For every action there is an equal and opposite reaction.

Sol. Answer (1)

11. A : It is difficult to move a cycle along a road with its brakes on.

R : Sliding friction is greater than rolling friction.

Sol. Answer (1)

12. A : It makes easier to walk on slippery muddy road if we throw some sand on it.

R : On throwing sand, frictional force of the surface increases.

Sol. Answer (1)

13. A : Banking of roads reduces the wear and tear of the tyres of automobiles.

R : By banking of the roads, one component of the normal reaction on the automobile contributes to necessary centripetal force.

Sol. Answer (1)

14. A : The centripetal and centrifugal forces never cancel each other.

R : They are action and reaction forces.

Sol. Answer (3)

15. A : Work done by friction can increase the kinetic energy of the body.

R : Friction is a type of contact force and it always opposes the relative motion or tendency of relative motion.

Sol. Answer (2)

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