4 Laws of Motion

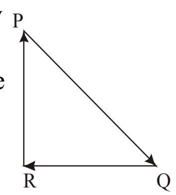
Trend Analysis with Important Topics & Sub-Topics

		2020		2019		2018		2017		2016	
Topic	**Sub-Topic**	**Qns.**	**LOD**	**Qns.**	**LOD**	**Qns.**	**LOD**	**Qns.**	**LOD**	**Qns.**	**LOD**
Ist, IInd & IIIrd Laws of Motion											
Motion of Connected Bodies, Pulley & Equilibrium of Forces	Acceleration of Motion of Connected Bodies	1	A								
	FBD					1	E				
Friction	Friction					1	A				
Circular Motion, Banking of Road	Centripetal Force			1	A			1	A		
	Maximum Safe Velocity									1	E
	Vel. Body Enter Vertical Loop									1	E

LOD - Level of Difficulty	E - Easy	A - Average	D - Difficult	Qns - No. of Questions

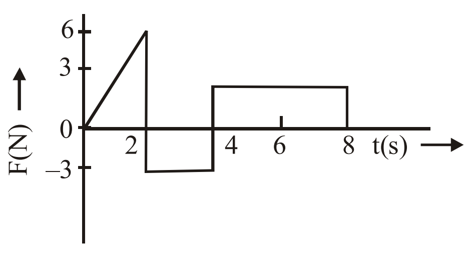
Topic 1: Ist, IInd & IIIrd Laws of Motion

1. A particle moving with velocity is acted by three forces shown by the vector triangle PQR. The velocity of the particle will :



(a) increase *[2019]*
(b) decrease
(c) remain constant
(d) change according to the smallest force

2. 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 zero to 8 s is : *[2014]*



(a) 24 Ns (b) 20 Ns
(c) 12 Ns (d) 6 Ns

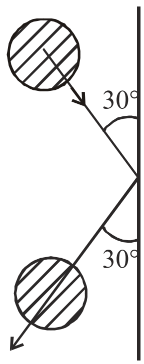
3. A stone is dropped from a height h. It hits the ground with a certain momentum P. If the same stone is dropped from a height 100% more than the previous height, the momentum when it hits the ground will change by : *[2012M]*
(a) 68% (b) 41%
(c) 200% (d) 100%

4. 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 *[2011]*
(a) MV (b) 1.5 MV
(c) 2 MV (d) zero

5. 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 *[2009]*
(a) 10 kg (b) 20 kg
(c) $10\sqrt{2}$ kg (d) $2\sqrt{10}$ kg

6. 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: *[2008]*
(a) Mv newton (b) 2 Mv newton
(c) $\frac{Mv}{2}$ newton (d) zero

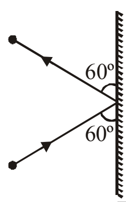
7. A 0.5 kg ball moving with speed of 12 m/s strikes a hard wall at an angle of 30° with the wall. It is reflected with the same speed and at the same angle. If the ball is in contact with the wall for 0.25 seconds, the average force acting on the wall is ***[2006]***



(a) 24 N (b) 12 N
(c) 96 N (d) 48 N

8. If *a* cricketer catches a ball of mass 150 gm moving with a velocity of 20 m/s, then he experiences a force of (Time taken to complete the catch is 0.1 sec.) ***[2001]***
(a) 300 N (b) 30 N
(c) 3 N (d) 0.3 N

9. A 3 kg ball strikes a heavy rigid wall with a speed of 10 m/s at an angle of 60°. It gets reflected with the same speed and angle as shown here. If the ball is in contact with the wall for 0.20s, what is the average force exerted on the ball by the wall? ***[2000]***



(a) 150 N
(b) zero
(c) $150\sqrt{3}$ N
(d) 300N

10. 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 average impulse imparted to the bullet? ***[1998]***
(a) 1.8 N-s (b) zero
(c) 9 N-s (d) 0.9 N-s

11. 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 ($g = 10\ ms^{-2}$) ***[1998]***
(a) 127.5 kg s^{-1} (b) 187.5 kg s^{-1}
(c) 185.5 kg s^{-1} (d) 137.5 kg s^{-1}

12. A 10 N force is applied on a body produces an acceleration of 1 m/s^2. The mass of the body is
(a) 5 kg (b) 10 kg ***[1996]***
(c) 15 kg (d) 20 kg

13. A ball of mass 150 g, moving with an acceleration 20 m/s^2, is hit by a force, which acts on it for 0.1 sec. The impulsive force is ***[1996]***
(a) 0.5 N (b) 0.1 N
(c) 0.3 N (d) 1.2 N

14. If the force on a rocket moving with a velocity of 300 m/sec is 345 N, then the rate of combustion of the fuel, is ***[1995]***
(a) 0.55 kg/sec (b) 0.75 kg/sec
(c) 1.15 kg/sec (d) 2.25 kg/sec

15. A satellite in a force free space sweeps stationary interplanetary dust at a rate (dM/dt) = αv. The acceleration of satellite is ***[1994]***
(a) $\dfrac{-2\alpha v^2}{M}$ (b) $\dfrac{-\alpha v^2}{M}$
(c) $\dfrac{-\alpha v^2}{2M}$ (d) $-\alpha v^2$

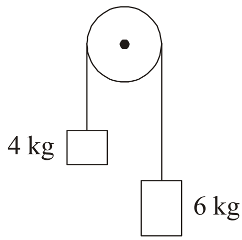
16. Physical independence of force is a consequence of ***[1991]***
(a) third law of motion
(b) second law of motion
(c) first law of motion
(d) all of these laws

17. A 600 kg rocket is set for a vertical firing. If the exhaust speed is 1000 ms^{-1}, the mass of the gas ejected per second to supply the thrust needed to overcome the weight of rocket is ***[1990]***
(a) 117.6 kg s^{-1} (b) 58.6 kg s^{-1}
(c) 6 kg s^{-1} (d) 76.4 kg s^{-1}

18. A particle of mass m is moving with a uniform velocity v_1. It is given an impulse such that its velocity becomes v_2. The impulse is equal to ***[1990]***
(a) $m[|v_2| - |v_1|]$ (b) $\frac{1}{2}m[v_2^2 - v_1^2]$
(c) $m[v_1 + v_2]$ (d) $m\,[v_2 - v_1]$

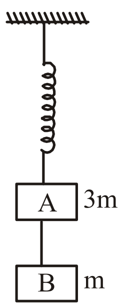
Topic 2: Motion of Connected Bodies, Pulley & Equilibrium of Forces

19. Two bodies of mass 4 kg and 6 kg are tied to the ends of a massless string. The string passes over a pulley which is frictionless (see figure). The acceleration of the system in terms of acceleration due to gravity (g) is: ***[2020]***



(a) g/2 (b) g/5
(c) g/10 (d) g

20. Two blocks A and B of masses 3 m and m respectively are connected by a massless and inextensible string. The whole system is suspended by a massless spring as shown in figure. The magnitudes of acceleration of A and B immediately after the string is cut, are respectively : ***[2017]***

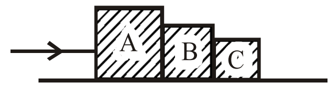


(a) $\frac{g}{3}, g$ (b) g, g
(c) $\frac{g}{3}, \frac{g}{3}$ (d) $g, \frac{g}{3}$

21. 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 centre) will be (T represents the tension in the string) : ***[2017]***

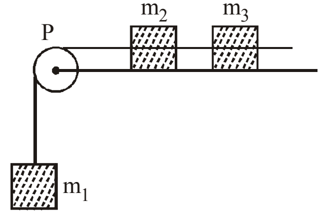
(a) $T + \frac{mv^2}{l}$ (b) $T - \frac{mv^2}{l}$
(c) Zero (d) T

22. 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 ***[2015]***



(a) 6 N (b) 8 N
(c) 18 N (d) 2 N

23. A system consists of three masses m_1, m_2 and m_3 connected by a string passing 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 = μ). The pulley is frictionless and of negligible mass. The downward acceleration of mass m_1 is : (Assume $m_1 = m_2 = m_3 = m$) ***[2014]***

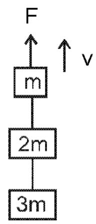


(a) $\frac{g(1 - g\mu)}{g}$
(b) $\frac{2g\mu}{3}$
(c) $\frac{g(1 - 2\mu)}{3}$
(d) $\frac{g(1 - 2\mu)}{2}$

24. A balloon with mass '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'? ***[2014]***

(a) $\frac{2ma}{g + a}$ (b) $\frac{2ma}{g - a}$
(c) $\frac{ma}{g + a}$ (d) $\frac{ma}{g - a}$

25. Three blocks with masses m, 2 m and 3 m 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) ***[2013]***



(a) 2 mg

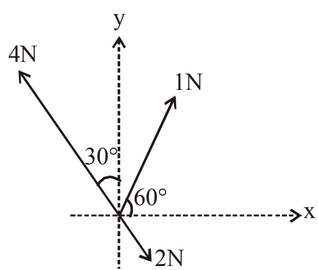
(b) 3 mg

(c) 6 mg

(d) zero

26. 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 $1.0\ m/s^2$. If $g = 10\ ms^{-2}$, the tension in the supporting cable is ***[2011]***
(a) 8600 N (b) 9680 N
(c) 11000 N (d) 1200 N

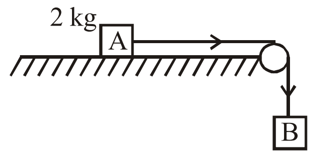
27. Three forces acting on a body are shown in the figure. To have the resultant force only along the y- direction, the magnitude of the minimum additional force needed is: ***[2008]***



(a) 0.5 N (b) 1.5 N
(c) $\frac{\sqrt{3}}{4}$ N (d) $\sqrt{3}$N

28. The mass of a lift is 2000 kg. When the tension in the supporting cable is 28000 N, then its acceleration is: ***[2009]***
(a) $4\ ms^{-2}$ upwards
(b) $4\ ms^{-2}$ downwards
(c) $14\ ms^{-2}$ upwards
(d) $30\ ms^{-2}$ downwards

29. The coefficient of static friction, 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. ($g = 10\ m/s^2$) ***[2004]***



(a) 0.4 kg (b) 2.0 kg
(c) 4.0 kg (d) 0.2 kg

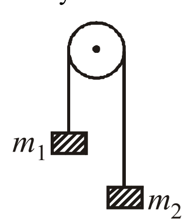
30. A block of mass *m* is placed on a smooth wedge of inclination θ. The whole system is accelerated horizontally so that the block does not slip on the wedge. The force exerted by the wedge on the block (g is acceleration due to gravity) will be ***[2004]***
(a) mg/cos θ (b) mg cos θ
(c) mg sin θ (d) mg

31. A man weighing 80 kg, 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? ($g = 10\ m/s^2$) ***[2003]***
(a) 1200 N (b) zero
(c) 400 N (d) 800 N

32. 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? ($g = 10\ m/s^2$) ***[2003]***
(a) $2.5\ m/s^2$ (b) $5\ m/s^2$
(c) $10\ m/s^2$ (d) $25\ m/s^2$

33. A lift weighing 1000 kg is moving upwards with an accelertion of $1\ m/s^2$. The tension in the supporting cable is ***[2002]***
(a) 980 N (b) 10800 N
(c) 9800 N (d) 8800 N

34. Two blocks $m_1 = 5$ gm and $m_2 = 10$ gm are hung vertically over a light frictionless pulley as shown here. What is the acceleration of the masses when they are left free? ***[2000]***



(a) g / 3 (b) g / 2
(c) g (d) g / 5
(where g is acceleration due to gravity)

35. 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 ***[1998]***
(a) 3 : 1 (b) 1 : 2
(c) 1 : 3 (d) 2 : 1

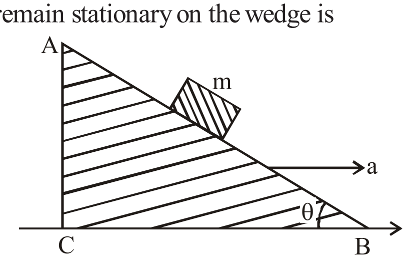
36. A monkey is decending from the branch of a tree with constant acceleration. If the breaking strength is 75% of the weight of the monkey, the minimum acceleration with which monkey can slide down without breaking the branch is ***[1993]***
(a) g (b) $\frac{3g}{4}$
(c) $\frac{g}{4}$ (d) $\frac{g}{2}$

Topic 3: Friction

37. A body of mass m is kept on a rough horizontal surface (coefficient of friction = $\propto$). A horizontal force is applied on the body, but it does not move. The resultant of normal reaction and the frictional force acting on the object is given by F, where F is, ***[NEET Odisha 2019]***
(a) $|\vec{F}| = mg$ (b) $|\vec{F}| = mg + \propto mg$
(c) $|\vec{F}| = \propto mg$ (d) $|\vec{F}| \le mg\sqrt{1+\mu^2}$

38. Which one of the following statements is incorrect? ***[2018]***
(a) Rolling friction is smaller than sliding friction.
(b) Limiting value of static friction is directly proportional to normal reaction.
(c) Coefficient of sliding friction has dimensions of length.
(d) Frictional force opposes the relative motion.

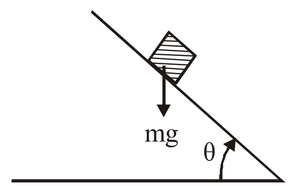
39. A block of mass m is placed on a smooth inclined wedge ABC of inclination θ as shown in the figure. The wedge is given an acceleration 'a' towards the right. The relation between a and θ for the block to remain stationary on the wedge is ***[2018]***



(a) $a = \frac{g}{\operatorname{cosec}\theta}$ (b) $a = \frac{g}{\sin\theta}$
(c) $a = g\tan\theta$ (d) $a = g\cos\theta$

40. 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 the table is μ_k. When the block A is sliding on the table, the tension in the string is ***[2015]***
(a) $\frac{(m_2 - \mu k\, m_1)g}{(m_1 + m_2)}$ (b) $\frac{m_1 m_2(1+\mu_k)g}{(m_1 + m_2)}$
(c) $\frac{m_1 m_2(1-\mu_k)g}{(m_1 + m_2)}$ (d) $\frac{(m_2 + \mu_k m_1)g}{(m_1 + m_2)}$

41. 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 4.0s. The coefficients of static and kinetic friction between the box and the plank will be, respectively : ***[2015 RS]***

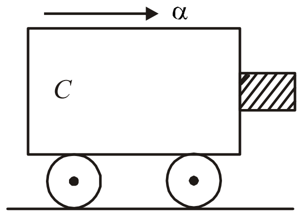


(a) 0.6 and 0.5 (b) 0.5 and 0.6
(c) 0.4 and 0.3 (d) 0.6 and 0.6

42. 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 ***[2013]***
(a) $\mu = \frac{2}{\tan\theta}$ (b) $\mu = 2\tan\theta$
(c) $\mu = \tan\theta$ (d) $\mu = \frac{1}{\tan\theta}$

43. A conveyor belt is moving at a constant speed of 2m/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 $g = 10\ ms^{-2}$, is ***[2011M]***
(a) 1.2 m (b) 0.6 m
(c) zero (d) 0.4 m

44. A block of mass m is in contact with the cart C as shown in the **Figure**. ***[2010]***

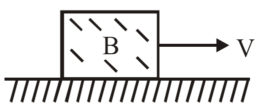


The coefficient of static friction between the block and the cart is μ. The acceleration α of the cart that will prevent the block from falling satisfies:

(a) $\alpha > \frac{mg}{\mu}$ (b) $\alpha > \frac{g}{\mu m}$

(c) $\alpha \geq \frac{g}{\mu}$ (d) $\alpha < \frac{g}{\mu}$

45. 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 ***[2007]***



(a) $g\mu/V$ (b) g/V

(c) V/g (d) $V/(g\mu)$.

46. A 100 N force acts horizontally on a block of 10 kg placed on a horizontal rough surface of coefficient of friction $\mu = 0.5$. If the acceleration due to gravity (g) is taken as 10 ms^{-2}, the acceleration of the block (in ms^{-2}) is ***[2002]***

(a) 2.5 (b) 10

(c) 5 (d) 7.5

47. A block of mass 1 kg is placed on a truck which accelerates with acceleration $5 m/s^2$. The coefficient of static friction between the block and truck is 0.6. The frictional force acting on the block is ***[2001]***

(a) 5 N (b) 6 N

(c) 5.88 N (d) 4.6 N

48. A person slides freely down a frictionless inclined plane while his bag falls down vertically from the same height. The final speeds of the man (V_M) and the bag (V_B) should be such that

(a) $V_M < V_B$ ***[2000]***

(b) $V_M = V_B$

(c) they depend on the masses

(d) $V_M > V_B$

49. A block has been placed on an inclined plane with the slope angle θ, block slides down the plane at constant speed. The coefficient of kinetic friction is equal to ***[1993]***

(a) $\sin\theta$ (b) $\cos\theta$

(c) g (d) $\tan\theta$

50. Consider a car moving along a straight horizontal road with a speed of 72 km/h. If the coefficient of static friction between the tyres and the road is 0.5, the shortest distance in which the car can be stopped is (taking g = 10 m/s^2) ***[1992]***

(a) 30 m (b) 40 m

(c) 72 m (d) 20 m

51. A heavy uniform chain lies on horizontal table top. If the coefficient of friction between the chain and the table surface is 0.25, then the maximum fraction of the length of the chain that can hang over one edge of the table is ***[1991]***

(a) 20% (b) 25%

(c) 35% (d) 15%

52. Starting from rest, a body slides down a 45° inclined plane in twice the time it takes to slide down the same distance in the absence of friction. The coefficient of friction between the body and the inclined plane is ***[1988]***

(a) 0.80 (b) 0.75

(c) 0.25 (d) 0.33

Topic 4: Circular Motion, Banking of Road

53. A block of mass 10 kg is in contact against the inner wall of a hollow cylindrical drum of radius 1 m. The coefficient of friction between the block and the inner wall of the cylinder is 0.1. The minimum angular velocity needed for the cylinder to keep the block stationary when the cylinder is vertical and rotating about its axis, will be : (g = 10 m/s^2) ***[2019]***

(a) $\sqrt{10}$ rad/s (b) $\frac{10}{2\pi}$ rad/s

(c) 10 rad/s (d) 10π rad/s

54. A mass m is attached to a thin wire and whirled in a vertical circle. The wire is most likely to break when: ***[2014]***

(a) the mass is at the highest point
(b) the wire is horizontal
(c) the mass is at the lowest point
(d) inclined at an angle of 60° from vertical

55. 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 : ***[2016]***

(a) $\sqrt{gR^2\left(\frac{\mu_s+\tan\theta}{1-\mu_s\tan\theta}\right)}$

(b) $\sqrt{gR\left(\frac{\mu_s+\tan\theta}{1-\mu_s\tan\theta}\right)}$

(c) $\sqrt{\frac{g}{R}\left(\frac{\mu_s+\tan\theta}{1-\mu_2\tan\theta}\right)}$

(d) $\sqrt{\frac{g}{R^2}\left(\frac{\mu_s+\tan\theta}{1-\mu_s\tan\theta}\right)}$

56. What is the minimum velocity with which a body of mass m must enter a vertical loop of radius R so that it can complete the loop? ***[2016]***

(a) $\sqrt{gR}$ (b) $\sqrt{2gR}$
(c) $\sqrt{3gR}$ (d) $\sqrt{5gR}$

57. Two stones of masses m and 2 m are whirled in horizontal circles, the heavier one in radius $\frac{r}{2}$ and the 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 : ***[2015 RS]***

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

58. 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 ***[NEET Kar. 2013]***

(a) 0° (b) $\frac{\pi}{3}$
(c) $\frac{\pi}{6}$ (d) $\frac{\pi}{4}$

59. 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 :

(a) 20 ms^{-1} (b) 30 ms^{-1} ***[2012]***
(c) 5 ms^{-1} (d) 10 ms^{-1}

60. 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 : ***[2012M]***

(a) $\sqrt{\mu_s mRg}$ (b) $\sqrt{Rg/\mu_s}$
(c) $\sqrt{mRg/\mu_s}$ (d) $\sqrt{\mu_s Rg}$

61. A 500 kg car takes a round turn of radius 50 m with a velocity of 36 km/h. The centripetal force is ***[1999]***

(a) 250 N (b) 750 N
(c) 1000 N (d) 1200 N

62. A body of mass 0.4 kg is whirled in a vertical circle making 2 rev/sec. If the radius of the circle is 1.2 m, then tension in the string when the body is at the top of the circle, is ***[1999]***

(a) 41.56 N (b) 89.86 N
(c) 109.86 N (d) 115.86 N

63. What will be the maximum speed of a car on a road turn of radius 30 m if the coefficient of friction between the tyres and the road is 0.4 (Take g = 9.8 m/s^2) ***[1995]***

(a) 10.84 m/s (b) 9.84 m/s
(c) 8.84 m/s (d) 6.84 m/s

64. A particle of mass *M* is moving in a horizontal circle of radius *R* with uniform speed V. When it moves from one point to a diametrically opposite point, its ***[1992]***

(a) kinetic energy changes by $MV^2/4$
(b) momentum does not change
(c) momentum changes by 2 *MV*
(d) kinetic energy changes by MV^2

65. When milk is churned, cream gets separated due to ***[1991]***

(a) centripetal force
(b) centrifugal force
(c) frictional force
(d) gravitational force

ANSWER KEY															
1	(c)	**9**	(c)	**17**	(c)	**25**	(d)	**33**	(b)	**40**	(b)	**47**	(a)	**54**	(c)
2	(c)	**10**	(d)	**18**	(d)	**26**	(c)	**34**	(a)	**41**	(a)	**48**	(b)	**55**	(b)
3	(b)	**11**	(b)	**19**	(b)	**27**	(a)	**35**	(a)	**42**	(b)	**49**	(d)	**56**	(d)
4	(c)	**12**	(b)	**20**	(a)	**28**	(a)	**36**	(c)	**43**	(d)	**50**	(b)	**57**	(d)
5	(c)	**13**	(c)	**21**	(d)	**29**	(a)	**37**	(d)	**44**	(c)	**51**	(a)	**58**	(d)
6	(a)	**14**	(c)	**22**	(a)	**30**	(a)	**38**	(c)	**45**	(d)	**52**	(b)	**59**	(c)
7	(a)	**15**	(b)	**23**	(c)	**31**	(a)	**39**	(c)	**46**	(c)	**53**	(c)	**60**	(d)
8	(b)	**16**	(c)	**24**	(a)	**32**	(a)								

61	(c)
62	(a)
63	(a)
64	(c)
65	(b)

Hints & Solutions

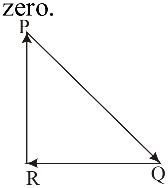
1. (c) As three forces are forming closed loop in same order, so net force is zero.

i.e., $\vec{F}_{net} = 0$

or $m\frac{d\vec{v}}{dt} = 0$

$\therefore$ Velocity of the particle

$\vec{v}$ = Constant



2. (c) Change in momentum,

$\Delta p = \int F dt$

= Area of F-t graph

= ar of Δ – *ar* of ▭ + *ar* of ▭

$= \frac{1}{2} \times 2 \times 6 - 3 \times 2 + 4 \times 3 = 12$ N-s

NOTES

According to Newton's 2nd law. $F \propto \frac{d\vec{p}}{dt} \Rightarrow F = K\frac{d\vec{p}}{dt}$ or, $F = \frac{d\vec{p}}{dt}$ [$\because k = 1$ in S.I & CGS system]

And $d\vec{p} = \vec{F}dt$

3. (b) Momentum $P = mv = m\sqrt{2gh}$

($\because v^2 = u^2 + 2gh$; Here $u = 0$)

When stone hits the ground momentum,

$P = m\sqrt{2gh}$

when same stone dropped from $2h$ (100% of initial) then momentum,

$P' = m\sqrt{2g(2h)} = \sqrt{2}P$

50% change in momentum, $\frac{(P' - P)}{P} \times 100\%$

$\Rightarrow \left(\frac{\sqrt{2}P - P}{P}\right) \times 100\% = (\sqrt{2} - 1) \times 100\%$

$\Rightarrow (1.414 - 1) \times 100\%$

$\Rightarrow 414 \times 100\% = 41.4\%$

Which is changed by 41% of initial.

4. (c) Impulse experienced by the body

= change in momentum

= MV – (–MV)

= 2MV

5. (c) $\vec{F} = 6\hat{i} - 8\hat{j} + 10\hat{k}$,

$|\vec{F}| = \sqrt{36 + 64 + 100} = 10\sqrt{2}$ N

$\left(\because F = \sqrt{F_x^2 + F_y^2 + F_z^2}\right)$

Given, $a = 1$ ms^{-2}

$\because F = ma \Rightarrow m = \frac{10\sqrt{2}}{1} = 10\sqrt{2}$ kg

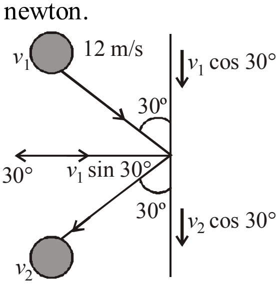
6. (a) $F = \frac{d(Mv)}{dt} = M\frac{dv}{dt} + v\frac{dM}{dt}$

$\therefore$ v is constant,

$\therefore F = v\frac{dM}{dt}$ But $\frac{dM}{dt} = M$ kg/s

$\therefore$ F = vM newton.

7. (a)



The magnetitude of both velocity v_1 and v_2 are equal. Components of velocity along the wall are equal and are in same direction.
But the component of velocity perpendicular to wall are equal but opposite in direction.
So, net change in momentum in perpendicular direction,
$\Delta P = mv_1 \sin 30° - (-mv_2 \sin 30°)$
$\Rightarrow \quad 2mv \sin 30° \qquad [|v_1|v_2|]$
Average force acting on the wall will be given by
$\Rightarrow \quad F x t = 2mv \sin 30°$

$$\Rightarrow \quad F = \frac{2mv \sin 30°}{t}$$

$$\Rightarrow \quad F = \frac{2 \times 0.5^2 \times 12 \times 1}{2 \times 0.25} = 24$$

$F = 24\text{N}$

8. (b) Net force experienced $= \dfrac{\text{Total Impulse}}{\text{Time taken}}$

$$= \frac{m\Delta v}{t} = 0.15 \times \frac{20}{0.1} = 30N$$

9. (c) Change in momentum along the wall
$= mv \cos 60^o - mv \cos 60^o = 0$
Change in momentum perpendicular to the wall
$= mv \sin 60^o - (-mv \sin 60^o) \quad = 2mv \sin 60^o$

$$\therefore \text{Applied force} = \frac{\text{Change in momentum}}{\text{Time}}$$

$$= \frac{2\ mv \sin 60^o}{0.20}$$

$$= \frac{2 \times 3 \times 10 \times \sqrt{3}}{2 \times 20} = 50 \times 3\sqrt{3}$$

$= 150\sqrt{3}$ newton

10. (d) Given $F = 600 - (2 \times 10^5 t)$
The force is zero at time t, given by
$0 = 600 - 2 \times 10^5\, t$

$$\Rightarrow \quad t = \frac{600}{2 \times 10^5} = 3 \times 10^{-3} \text{ seconds}$$

$$\therefore \text{ Impulse} = \int_0^t F dt = \int_0^{3\times 10^{-3}} (600 - 2 \times 10^5 t)\, dt$$

$$= \left[600t - \frac{2 \times 10^5 t^2}{2}\right]_0^{3\times 10^{-3}}$$

$= 600 \times 3 \times 10^{-3} - 10^5 (3 \times 10^{-3})^2$
$= 1.8 - 0.9 = 0.9$ Ns

> **NOTES** In case of impulse or motion of a charged particle in an alternating electric field, force is time dependent.

11. (b) Given : Mass of rocket (m) = 5000 kg
Exhaust speed (v) = 800 m/s
Acceleration of rocket (a) = 20 m/s^2
Gravitational acceleration (g) = 10 m/s^2

$$\text{Thrust}, \Rightarrow \frac{vdm}{dt}$$

We know that upward force,
$F = m(g + a) = 5000\,(10 + 20)$
$= 5000 \times 30 = 150000$ N

This thrust gives upward force, $F = \dfrac{vdm}{dt}$

We also know that amount of gas ejected

$$\Rightarrow \left(\frac{dm}{dt}\right) = \frac{F}{v} = \frac{150000}{800} = 187.5 \text{ kg/s}$$

12. (b) By Newton's IInd law of motion, $F = ma$
$\Rightarrow 10 = m(1) \Rightarrow m = 10$ kg.

13. (c) Mass = 150 gm $= \dfrac{150}{1000}$ kg
Force = Mass × acceleration

$$= \frac{150}{1000} \times 20\text{N} = 3\text{ N}$$

Impulsive force $= F \cdot \Delta t = 3 \times 0.1 = 0.3$ N

14. (c) Velocity of the rocket (u) = 300 m/s and force (F) = 345N. According to Newton's second law, thrust (force) = Rate of change of linear momentum.

$$\frac{F}{u} = \left(\frac{dm}{dt}\right) = 1.15 \text{kg / sec}$$

15. (b) Thrust on the satellite,

$$F = \frac{-vdM}{dt} = -v(\alpha v) = -\alpha v^2$$

$$\text{Acceleration} = \frac{F}{M} = \frac{-\alpha v^2}{M}$$

16. (c) Newton's first law of motion is related to physical independence of force.

> **NOTES** If no net force acts on a body, then the velocity of the body cannot change *i.e.*, the body cannot accelerate.

17. (c) Thrust = weight

$$\Rightarrow \frac{udM}{dt} = mg \Rightarrow \frac{dM}{dt} = \frac{mg}{u}$$

$$= \frac{600 \times 10}{1000} = 6 \text{ kg s}^{-1}$$

18. (d) Impulse = final momentum – initial momentum = $m(v_2 - v_1)$

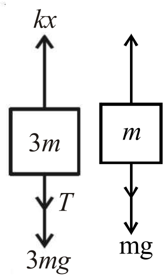
19. (b) Given : Mass $M_1 = 4$ kg and $M_2 = 6$ kg.
Acceleration of the system,

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

$$\therefore a = \frac{(6-4)g}{6+4} = \frac{g}{5}$$

NOTES Here no option is given according to acceleration of COM of the system.

20. (a) Before cutting the string



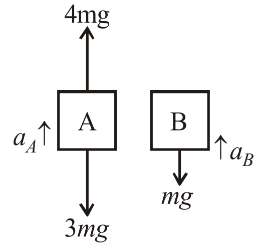
$kx = T + 3$ mg ...(i)
T = mg ...(ii)
Force an string,
$\Rightarrow$ kx = 4mg
After cutting the string T = 0

For block A: $3ma_A$ = 4mg – 3mg

$$a_A = \frac{4mg - 3mg}{3m} = \frac{g}{3}$$

$$a_A = \frac{g}{3}$$

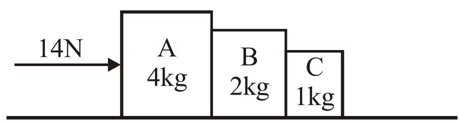
For block B: ma_B = mg
$a_B = g$



21. (d) Net force on particle in uniform circular motion is centripetal force $\left(\frac{mv^2}{\ell}\right)$ which is provided by tension in string so the net force will be equal to tension *i.e.*, T.

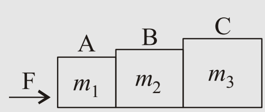
22. (a) Acceleration of system, $a = \frac{F_{net}}{M_{total}}$

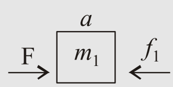
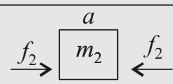
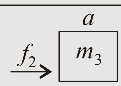
$$= \frac{14}{4+2+1} = \frac{14}{7} = 2 \text{ m/s}^2$$



The contact force between A and B
= $(m_B + m_C) \times a = (2 + 1) \times 2 = 6$N

NOTES



	$F - f_1 = m_2 a$	$a = \frac{F}{m_1 + m_2 + m_3}$
	$f_1 - f_2 = m_2 a$	$f_1 = \frac{(m_2 + m_3)F}{m_1 + m_2 + m_3}$
	$f_2 = m_2 a$	$f_2 = \frac{m_3 F}{m_1 + m_2 + m_3}$

23. (c) Acceleration

$$= \frac{\text{Net force in the direction of motion}}{\text{Total mass of system}}$$

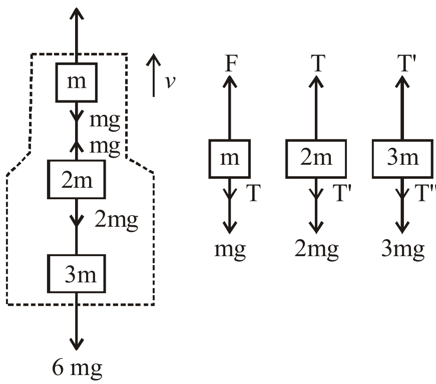
$$= \frac{m_1 g - \mu(m_2 + m_3)g}{(m_1 + m_2 + m_3)} = \frac{g}{3}(1 - 2\mu)$$

($\because$ $m_1 = m_2 = m_3 = m$ given)

24. (a) Let upthrust of air be F_a then
For downward motion of balloon,
$F_a = mg - ma \Rightarrow Fa = m(g - a)$ ...(i)
For upward motion,
$F_a - (m - \Delta m)g = (m - \Delta m)a$ ...(ii)
From equation (i) and (ii),

Therefore, $\Delta m = \dfrac{2ma}{(g + a)}$

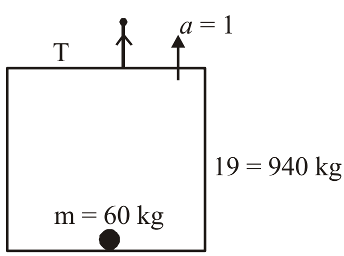
25. (d)



From figure
$F = 6\,mg$,
As speed is constant, acceleration $a = 0$
$\therefore 6\,mg = 6ma = 0, F = 6\,mg$
$\therefore T = 5\,mg, T' = 3\,mg$
$T'' = 0$
F_{net} on block of mass 2 m
$= T - T' - 2\,mg = 0$

NOTES: As all blocks are moving with constant speed, then acceleration is zero, so force is zero.
$\because v$ = constant
so, $a = 0$, Hence, $F_{net} = ma = 0$

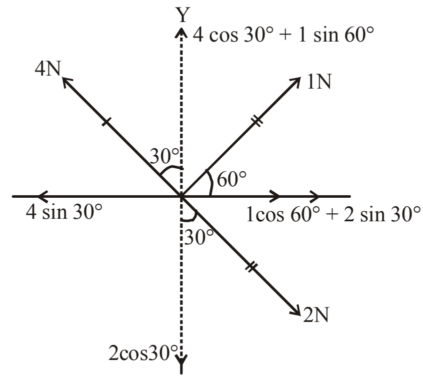
26. (c)



Total mass $= (m + m) = (60 + 940)$ kg $= 1000$ kg
Let T be the tension in the supporting cable, then
$T - 1000g = 1000 \times 1$ [$\because a = 1$ m/sec]
$\Rightarrow T = 11000$ N

27. (a) The components of 1 N and 2N forces along $+x$-axis $= 1\cos 60° + 2\sin 30°$

$$= 1\times\frac{1}{2} + 2\times\frac{1}{2} = \frac{1}{2} + 1 = \frac{3}{2} = 1.5\text{N}$$



The component of 4 N force along $-x$-axis

$= 4\sin 30° = 4\times\dfrac{1}{2} = 2\text{N}$.

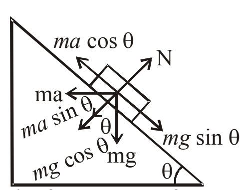
Therefore, if a force of 0.5N is applied along $+x$-axis, the resultant force along x-axis will become zero and the resultant force will be obtained only along y-axis.

28. (a) Net force, $F = T - mg$
$ma = T - mg$
$2000\,a = 28000 - 20000 = 8000$

$$a = \frac{8000}{2000} = 4\,\text{ms}^{-2} \uparrow$$

29. (a) Condition for the max value of mass of block B so that two blocks do not move is,
$m_B g = \mu_s m_A g$
$\Rightarrow m_B = \mu_s m_A$
or, $m_B = 0.2 \times 2 = 0.4$ kg

30. (a) According to the condition,



$N = m\,a\sin\theta + mg\cos\theta$ .....(1)
Also, $m\,g\sin\theta = m\,a\cos\theta$ ....(2)
From (1) & (2), $a = g\tan\theta$

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

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

or, $N = \dfrac{mg}{\cos\theta}$

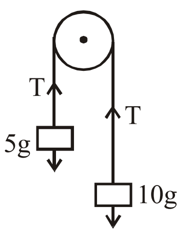
NOTES: The condition for the body to be at rest relative to the inclined plane, $a = g\sin\theta - b\ \text{con}\theta = 0$ Horizontal acceleration, $b = g\ \tan\theta$.

31. (a) Reading of the scale
$=$ Apparent wt. of the man $= m(g+a)$
$= 80\,(10+5) = 1200\ \text{N}$

32. (a) T = Tension caused in string by monkey
$= m\,(g+a)$
$\therefore T \le 25 \times 10 \Rightarrow 20(10+a) \le 250$
or, $10 + a \le 12.5 \Rightarrow a \le 2.5$

33. (b) $T - (1000 \times 9.8) = 1000 \times 1$
$\Rightarrow T = 10800\ \text{N}$

34. (a) Let T be the tension in the string.



$\therefore 10g - T = 10a$ ....(i)
$T - 5g = 5a$ ....(ii)
Adding (i) and (ii),

$5g = 15a \Rightarrow a = \dfrac{g}{3}\ \text{m/s}^2$

NOTES: Whe pulley have a finite mass m then acceleration,

$$a = \frac{m_1 - m_2}{m_1 + m_2 + \frac{m}{2}}$$

35. (a) In case (i) we have
$T_1 - (1 \times g) = 1 \times 4.9$
$\Rightarrow T_1 = 9.8 + 4.9 = 14.7\ \text{N}$
In case (ii), $1 \times g - T_2 = 1 \times 4.9$
$\Rightarrow T_2 = 9.8 - 4.9 = 4.9\ \text{N}$

$\therefore \dfrac{T_1}{T_2} = \dfrac{14.7}{4.9} = \dfrac{3}{1}$

36. (c) Let T be the tension in the branch of a tree when monkey is descending with acceleration a. Then $mg - T = ma$; and $T = 75\%$ of weight of monkey,

$\therefore ma = mg - \left(\dfrac{75}{100}\right) mg = \left(\dfrac{1}{4}\right) mg$

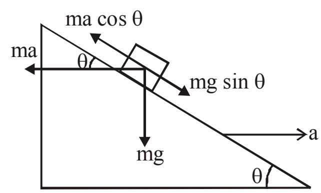
or $a = \dfrac{g}{4}$.

37. (d) Since body does not move hence it is in equilibrium.
f_r = frictional force which is less than or equal to limiting friction.
Now $N = mg$
Hence $\vec{F} = \vec{N} + \vec{f_r}$
$|\vec{F}| \le \sqrt{(mg)^2 + (\mu mg)^2}$
$|\vec{F}| \le mg\sqrt{1+\mu^2}$

38. (c) Coefficient of friction or sliding friction has no dimension.

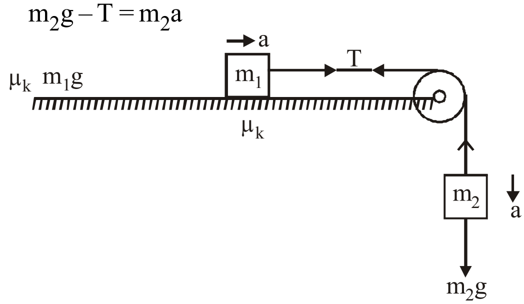
$f = \mu_s N \Rightarrow \mu_s = \dfrac{f}{N} = [M^0L^0T^0]$

39. (c) Let the mass of block is m. It will remains stationary if forces acting on it are in equilibrium. *i.e.*, ma cos θ = mg sin θ ⇒ a = g tan θ



Here ma = Pseudo force on block, mg = weight.

40. (b) For the motion of both the blocks
$m_1 a = T - \mu_k m_1 g$
$m_2 g - T = m_2 a$



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

$$m_2 g - T = (m_2)\left(\frac{m_2 g - \mu_k m_1 g}{m_1 + m_2}\right)$$

solving we get tension in the string

$$T = \frac{m_1 m_2 g\,(1+\mu_k)\,g}{m_1 + m_2}$$

41. (a) Coefficient of static friction, $\mu_s = \tan\theta$

$\Rightarrow \mu_s = \tan 30° = \dfrac{1}{\sqrt{3}} = 0.577 \cong 0.6$

So, distance covered by plank,

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

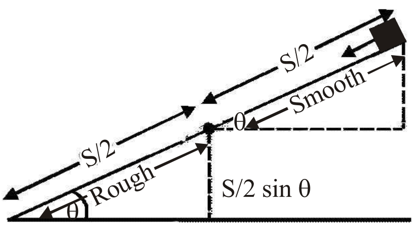
where, $u = 0$ and $a = g\sin\theta - \mu_k(g)\cos\theta$

$$4 = \frac{1}{2}a(4)^2 \Rightarrow a = \frac{1}{2} = 0.5$$

[$\because$ $\theta = 30°$, $s = 4$m and $t = 4$s given]

$$\Rightarrow \mu_k = \frac{0.9}{\sqrt{3}} = 0.5$$

42. (b)



For upper half of inclined plane
$v^2 = u^2 + 2a\, S/2 = 2\,(g\sin\theta)\, S/2 = gS\sin\theta$
For lower half of inclined plane
$0 = u^2 + 2g(\sin\theta - \mu\cos\theta)\, S/2$
$\Rightarrow \quad -gS\sin\theta = gS(\sin\theta - \mu\cos\theta)$
$\Rightarrow \quad 2\sin\theta = \mu\cos\theta$

$$\Rightarrow \quad \mu = \frac{2\sin\theta}{\cos\theta} = 2\tan\theta$$

43. (d) Frictional force on the box $f = \mu mg$

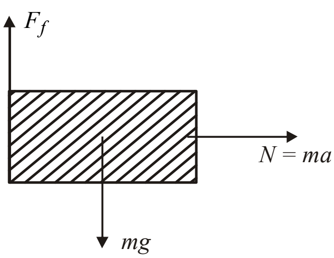
$\therefore$ Acceleration in the box, $a = \frac{f}{m} = \frac{\mu mg}{m}$

$a = \mu g = 5\ ms^{-2}$
$v^2 = u^2 + 2as$
$\Rightarrow \quad 0 = 2^2 + 2 \times (5)\, s$

$\Rightarrow s = -\frac{2}{5}$ w.r.t. belt

$\Rightarrow$ distance = 0.4 m

44. (c) Forces acting on the block are as shown in the fig. Normal reaction N is provided by the force ma due to acceleration α



$\therefore \quad N = ma$

For the block not to fall, frictional force, $F_f \ge mg$
$\Rightarrow \quad \mu N \ge mg$
$\Rightarrow \quad \mu ma \ge mg$
$\Rightarrow \quad a \ge g/\mu$

NOTES: When a cart moves with some acceleration towards right then a psendo force (ma) acts on block towards left. This force ma is action force by a block on cart.

45. (d) Friction is the retarding force for the block
$F = ma = \mu R = \mu mg$
Therefore, from the first equation of motion
$v = u - at$

$$0 = V - \mu g \times t \Rightarrow \frac{V}{\mu g} = t$$

46. (c) $a = \frac{F - \mu R}{m} = \frac{100 - 0.5 \times (10 \times 10)}{10} = 5\,ms^{-2}$

47. (a) Maximum friction force = μmg
$= .6 \times 1 \times 9.8 = 5.88$ N
But here required friction force
$= ma = 1 \times 5 = 5$ N

NOTES: For a body placed on a moving body and Ist body not to slide - applied force $F <$ limiting friction ($= Ms\ mg$) combined system will move together with common acceleration $a_1 = a_2 = \frac{F}{M+m}$.

48. (b) As there is only gravitational field which works. We know it is conservative field and depends only on the end points. So, $V_M = V_B$

49. (d) When the block slides down the plane with a constant speed, then the inclination of the plane is equal to angle of repose (θ).
Coeff. of friction = tan of the angle of repose
= tan θ.

50. (b) Here u = 72 km/h = 20 m/s; v = 0;
$a = -\mu g = -0.5 \times 10 = -5\ m/s^2$
As $v^2 = u^2 + 2as$,

$$\therefore \quad s = \frac{(v^2 - u^2)}{2a} = \frac{(0-(20)^2}{2\times(-5)} = 40\,\text{m}$$

51. (a) The force of friction on the chain lying on the table should be equal to the weight of the hanging chain. Let
ρ = mass per unit length of the chain
μ = coefficient of friction
l = length of the total chain
x = length of hanging chain
Now, $\mu(l - x)\rho g = x\rho g$ or $\mu(l - x) = x$
or $\mu l = (\mu + 1)x$ or $x = \mu l/(\mu + 1)$

$\therefore\ x = \frac{0.25l}{(0.25+1)} = \frac{0.25l}{1.25} = 0.2l$

$\frac{x}{l} = 0.2 \Rightarrow \frac{x}{\ell}\times 100 = 20\%$

52. (b) In presence of friction $a = (g\sin\theta - \mu g\cos\theta)$
$\therefore$ Time taken to slide down the plane

$$t_1 = \sqrt{\frac{2s}{a}} = \sqrt{\frac{2s}{g(\sin\theta - \mu\cos\theta)}}$$

In absence of friction, $t_2 = \sqrt{\frac{2s}{g\sin\theta}}$

According to the condition,

$t_1 = 2t_2 \quad \therefore\ t_1^2 = 4t_2^2$

or, $\frac{2s}{g(\sin\theta - \mu\cos\theta)} = \frac{2s\times 4}{g\sin\theta}$

$\sin\theta = 4\sin\theta - 4\mu\cos\theta$

$\mu = \frac{3}{4}\tan\theta = \frac{3}{4} = 0.75$

53. (c) Given mass of block, m = 10 kg; radius of cylindrical drum, r = 1m; coefficient of friction between the block and the inner wall of the cylinder $\mu = 0.1$;
Minimum angular velocity ω_{min}
For equilibrium of the block limiting friction

$f_L \geq mg$

$\Rightarrow \mu N \geq mg$

$\Rightarrow \mu r\omega^2 \geq mg$
Hrere, $N = mr\omega^2$

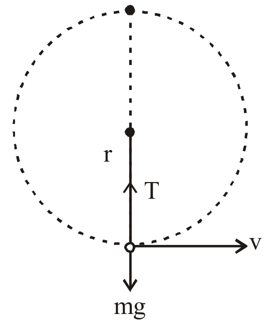
or, $m \geq \sqrt{\frac{g}{r\mu}}$

or, $\omega_{min} = \sqrt{\frac{g}{r\mu}}$

$\therefore\ \omega_{min} = \sqrt{\frac{10}{0.1\times 1}} = 10$ rad/s

54. (c) $T - mg = \frac{mv^2}{r}$ [centripetal force] $= \frac{mv^2}{r}$

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



As the velocity is maximum at lowest point so tension is maximum at the lowest position of mass, so the chance of breaking is maximum.

55. (b) On a banked road,

$$\frac{V_{max}^2}{Rg} = \left(\frac{\mu_s + \tan\theta}{1 - \mu_s\tan\theta}\right)$$

Maximum safe velocity of a car on the banked road

$$V_{max} = \sqrt{Rg\left[\frac{\mu_s + \tan\theta}{1 - \mu_s\tan\theta}\right]}$$

56. (d) $\sqrt{5gR}$ is the minimum velocity which the body must possess at the bottom of the circle so as to go round the circle completely.

57. (d) According to question, two stones experience same centripetal force

i.e., $F_{C_1} = F_{C_2}$

or, $\frac{mv_1^2}{r} = \frac{2mv_2^2}{(r/2)}$ or, $V_1^2 = 4V_2^2$

So, $V_1 = 2V_2$ *i.e.*, $n = 2$

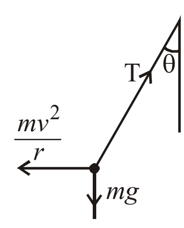
58. (d) Given; speed = 10 m/s; radius $r = 10$ m
Angle made by the wire with the vertical is θ.
Then, $T\cos\theta = mg$

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

So,

$\tan\theta = \frac{v^2}{rg} = \frac{10^2}{10\times 10} = 1$

$\Rightarrow \theta = 45° = \frac{\pi}{4}$



59. (c) For banking, $\tan\theta = \frac{V^2}{Rg}$

$$\tan 45^\circ = \frac{V^2}{90\times 10} = 1$$

$V = 30$ m/s

NOTES

If friction is present then maximum safe speed, on a banked frictional road, $V = \sqrt{\frac{Rg(\mu + \tan\theta)}{1-\mu\tan\theta}}$

60. (d) For smooth driving maximum speed of car v then,

$$\frac{mv^2}{R} = \mu_s mg$$

$$v = \sqrt{\mu_s Rg}$$

61. (c) Centripetal force $= \frac{mv^2}{r} = \frac{500\times(10)^2}{50}$

$= 1000$ N [$\because$ 36 km/hr = 10 m/s]

62. (a) Given : Mass (m) = 0.4 kg
Its frequency (n) = 2 rev/sec
Radius (r) = 1.2 m. We know that linear velocity of the body (v) = $\omega r = (2\pi n)r$
$= 2\times 3.14\times 2\times 1.2 = 15.08$ m/s.
Therefore, tension in the string when the body is at the top of the circle (T)

$$= \frac{mv^2}{r} - mg = \frac{0.4\times(15.08)^2}{2} - (0.4\times 9.8)$$

$= 45.78 - 3.92 = 41.56$ N

63. (a) $r = 30\ m$ and $\mu = 0.4$.

$$v_{max} = \sqrt{\mu rg} = \sqrt{0.4\times 30\times 9.8} = 10.84 \text{ m/s}$$

64. (c) On the diametrically opposite points, the velocities have same magnitude but opposite directions. Therefore, change in momentum is $MV - (-MV) = 2MV$

65. (b) Cream gets separated from a churned milk due to centrifugal force.

NOTES

Centrifugal force is a pseudo force that is equal and opposite to the centripetal force.
Centripetal force can be mechanical, electrical or magnetic force.