

# JDLCCCE-JE 2023

Jharkhand Diploma Level Combined Competitive Exam

**Junior Engineer Examination**  
Jharkhand Staff Selection Commission

## 2700 MCQs

Fully solved multiple choice questions  
*with* detailed explanations

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Practice Book  
**General Engineering**





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**2700 MCQs for Jharkhand Diploma Level Combined Competitive Exam : General Engineering**

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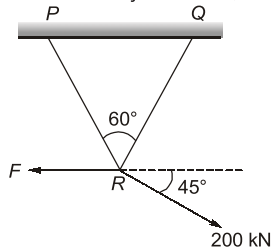
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# UNIT 1

## Engineering Mechanics and Theory of Machines

- Q.1** The force  $F$  such that both the bars  $PR$  and  $QR$  ( $PR$  and  $QR$  are equal in length) as shown in the figure are identically loaded, is



- (a) 200 kN (b) 100 kN  
(c) 141.4 kN (d) 173.2 kN

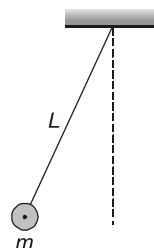
- Q.2** An ideal spring with spring constant  $k$  is hung from the ceiling and a block of mass  $M$  is attached to its lower end. The mass is released with the spring initially unstretched, then the maximum extension in the spring is

- (a)  $\frac{2Mg}{k}$  (b)  $\frac{Mg}{k}$   
(c)  $\frac{Mg}{2k}$  (d)  $\frac{Mg}{4k}$

- Q.3** A piece of wire is bent in the shape of a parabola  $y = kx^2$  ( $y$ -axis vertical) with a bead of mass  $m$  on it. The bead can slide on the wire without friction. It stays at the lowest point of the parabola when the wire is at rest. The wire is now accelerated parallel to the  $x$ -axis with a constant acceleration  $a$ . The distance of the new equilibrium position of the bead, where the bead can stay at rest with respect to the wire, from the  $y$ -axis is:

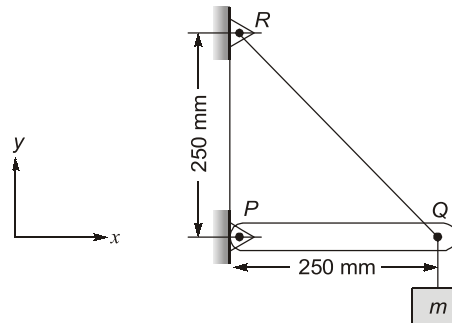
- (a)  $\frac{a}{4gk}$  (b)  $\frac{2a}{gk}$   
(c)  $\frac{a}{2gk}$  (d)  $\frac{a}{gk}$

- Q.4** A ball of mass 0.25 kg is attached to the end of a string having length 0.5 m. The ball is rotated on a horizontal circular path about vertical axis. The maximum tension that the string can bear is 648 N. The maximum possible value of angular velocity of ball (in radian/s) is



- (a) 27 (b) 36  
(c) 54 (d) 72

- Q.5** A mass 25 kg is suspended from a weightless bar  $PQ$  which is supported by a cable  $QR$  and a pin at  $P$  as shown in figure below. The pin reactions at  $P$  on the bar  $PQ$  are  
[Take  $g = 10 \text{ m/s}^2$ ]



- (a)  $R_x = 250 \text{ N}$ ,  $R_y = 250\sqrt{2}$   
(b)  $R_x = 250 \text{ N}$ ,  $R_y = 0$   
(c)  $R_x = 500 \text{ N}$ ,  $R_y = 250\sqrt{2}$   
(d)  $R_x = 500 \text{ N}$ ,  $R_y = 0$

- Q.6** Match **List-I** with **List-II** and select the correct answer using the codes given below the lists:

### List-I

- A. Stability  
B. Collision of particles  
C. Spinning top  
D. Satellite motion

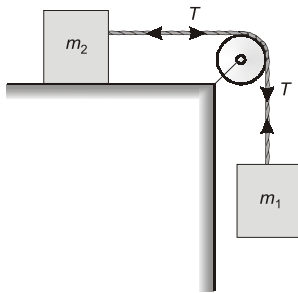
### List-II

1. Minimum potential energy  
2. Minimum kinetic energy  
3. Euler's equation of motion  
4. Conservation of moment of momentum  
5. Impulse-momentum principle

Codes:

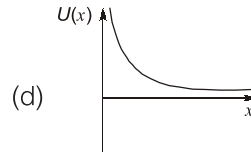
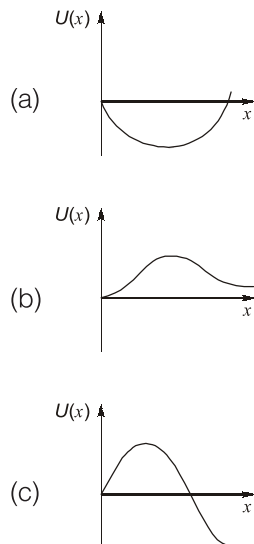
	A	B	C	D
(a)	1	2	3	4
(b)	1	5	4	3
(c)	2	5	3	4
(d)	2	5	1	3

- Q.7** In the given figure, two bodies of masses  $m_1$  and  $m_2$  are connected by a light inextensible string passes over a smooth pulley. Mass  $m_2$  lies on a smooth horizontal plane. When mass  $m_1$  moves downwards, the acceleration (in  $\text{m/s}^2$ ) of the two bodies is equal to

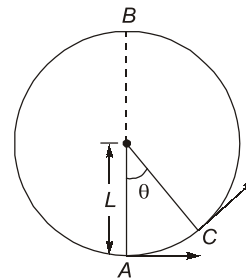


- (a)  $\frac{m_2 g}{m_1 - m_2}$       (b)  $\frac{m_1 g}{m_1 - m_2}$   
(c)  $\frac{m_1 g}{m_1 + m_2}$       (d)  $\frac{m_2 g}{m_1 + m_2}$

- Q.8** A particle, which is constrained to move along the  $x$ -axis, is subjected to a force in the same direction which varies with the distance  $x$  of the particle from the origin as  $F(x) = -kx + ax^3$ . Here  $k$  and  $a$  are positive constants. For  $x \geq 0$ , the functional graphically form of the potential energy  $U(x)$  of the particle is



- Q.9** A bob of mass  $M$  is suspended by a massless string of length  $L$ . The horizontal velocity  $v$  at position  $A$  is just sufficient to make it reach the point  $B$ . The angle  $\theta$  at which the speed of the bob is half of that at  $A$ , satisfies



- (a)  $\theta = \frac{\pi}{2}$       (b)  $\frac{\pi}{4} < \theta < \frac{\pi}{2}$   
(c)  $\frac{3\pi}{4} < \theta < \pi$       (d)  $\frac{\pi}{2} < \theta < \frac{3\pi}{4}$

- Q.10** Particles of mass 12 kg and 6 kg are released from a separation of 90 m and move towards each other under the mutual gravitational force. They will hit each other at a distance of  
(a) 20 m from the initial position of 6 kg  
(b) 20 m from the initial position of 12 kg  
(c) 30 m from the initial position of 12 kg  
(d) 30 m from the initial position of either mass

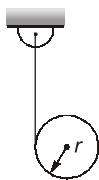
- Q.11** A ball  $A$  of mass  $M$  falls under gravity from a height  $h$  and strikes another ball  $B$  of mass 2 m which is supported at rest on a spring of stiffness  $k$ . Assume perfectly inelastic impact. Immediately after the impact

- (a) the velocity of ball  $A$  is zero  
(b) the velocity of ball  $A$  is  $\frac{1}{2}\sqrt{2gh}$   
(c) the velocity of both balls is  $\frac{1}{3}\sqrt{2gh}$   
(d) the velocity of both balls is  $\frac{1}{2}\sqrt{2gh}$

**Q.12** A solid sphere is rolling without slipping on a horizontal surface. The ratio of its rotational kinetic energy to its translational kinetic energy is

- (a)  $\frac{7}{2}$  (b)  $\frac{2}{5}$   
(c)  $\frac{2}{7}$  (d)  $\frac{2}{9}$

**Q.13** A cord is wrapped around a cylinder of radius  $r$  and mass  $m$  as shown in the given figure. If the cylinder is released from rest, the velocity of the cylinder, after it has moved through a distance  $h$  will be



- (a)  $\sqrt{2gh}$  (b)  $\sqrt{\frac{gh}{3}}$   
(c)  $\sqrt{gh}$  (d)  $\sqrt{\frac{4gh}{3}}$

**Q.14** An elevator weighting 100 kN attains an upward velocity of 10 m/s in two seconds with uniform acceleration. The tension in the cable will be

- (a) 150 kN (b) 200 kN  
(c) 50 kN (d) 25 kN

**Q.15** Match **List-I** with **List-II** and select the correct answer using the codes given below the lists:

**List-I**

- A. Newton's first law of motion  
B. Newton's second law of motion  
C. Lami's theorem  
D. Polygon law of forces

**List-II**

- Determination of the resultant of non-parallel forces.
- Definition of the general condition of equilibrium.
- Determines the rate of change of momentum.
- Estimation of the three forces on a body in equilibrium.

**Codes:**

- |     | A | B | C | D |
|-----|---|---|---|---|
| (a) | 2 | 3 | 4 | 1 |
| (b) | 2 | 1 | 3 | 4 |
| (c) | 1 | 2 | 4 | 3 |
| (d) | 1 | 3 | 2 | 4 |

**Q.16** In a two-particle system with particle masses  $m_1$  and  $m_2$ , the first particle is pushed towards the centre of mass through a distance  $d$ , the distance through which second particle must be moved to keep the centre of mass at the same position is

- (a)  $\frac{m_1}{m_2}d$  (b)  $\frac{m_2}{m_1}d$   
(c)  $\frac{(m_1 + m_2)}{m_1}d$  (d)  $\frac{m_1 d}{(m_1 + m_2)}$

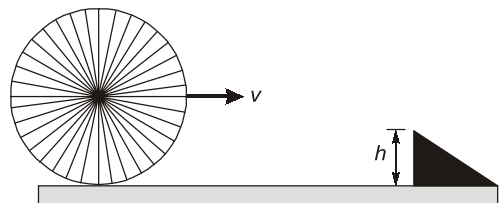
**Q.17** Two solid cylinders A and B of same radius start rolling down on a fixed inclined plane from the same height at the same time. Cylinder A has most of its mass concentrated near its surface, while B has most of its mass concentrated near the axis. Which statement is correct?

- (a) Both cylinders A and B reach the ground at the same time  
(b) Cylinder A has larger linear acceleration than cylinder B  
(c) Both cylinders reach the ground with same translational kinetic energy  
(d) Cylinder B reaches the ground with larger angular speed

**Q.18** A body of mass 1.5 kg rotating about an axis with angular velocity of 0.3 rad/s has an angular momentum of 7.2 kgm<sup>2</sup>/s. The radius of gyration of the body about an axis of rotation is

- (a) 0.6 m (b) 1.6 m  
(c) 2 m (d) 4 m

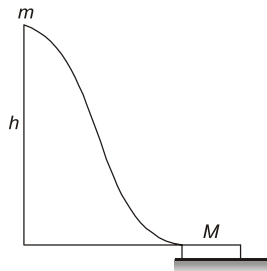
**Q.19** A wheel of centroidal radius of gyration  $k$  is rolling on a horizontal surface with constant velocity. It comes across an obstruction of height  $h$ . Because of its rolling speed, it just overcomes the obstruction. To determine  $v$ , one should use the principle(s) of conservation of



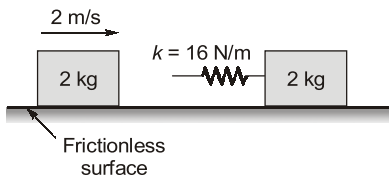
- (a) Energy  
(b) Linear momentum  
(c) Energy and linear momentum  
(d) Energy and angular momentum

- Q.20** The masses of five balls at rest in a straight line are in geometric progression with ratio 2 and their coefficients of restitution are each  $\frac{2}{3}$ . If the first ball be started towards the second with velocity  $u$ , then the velocity communicated to 5th ball is
- (a)  $\left(\frac{5}{9}\right)u$                       (b)  $\left(\frac{5}{9}\right)^2 u$
- (c)  $\left(\frac{5}{9}\right)^3 u$                       (d)  $\left(\frac{5}{9}\right)^4 u$

- Q.21** A small disc of mass  $m$  slides down a smooth hill of height  $h$  from rest and gets on to a plank of mass  $M$  lying on the horizontal plane at the hill. Due to friction between the disc and the plank, the disc slows down and after a certain moment, moves in one piece with the plank. Then the work performed by the friction force in this process is (Ignore friction between plank and plane)



- (a)  $\frac{M}{m}gh$                       (b)  $\frac{mM}{m+M}gh$
- (c)  $\frac{mM}{m-M}gh$                       (d) zero
- Q.22** In the arrangement shown below, match **List-I** with **List-II** and select the correct answer using the codes given below the lists:



**List-I**

- A. Velocity of centre of mass
- B. Velocity of combined mass when compression in the spring is maximum
- C. Maximum compression in the spring
- D. Maximum potential energy stored in the spring

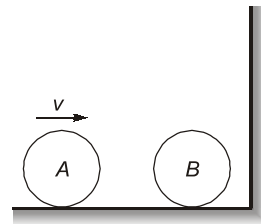
**List-II**

- 2 SI unit
- 1 SI unit
- 0.5 SI unit
- 0.25 SI unit

**Codes:**

	A	B	C	D
(a)	2	1	3	4
(b)	2	2	3	1
(c)	1	2	2	3
(d)	1	2	4	3

- Q.23** Two balls, shown in figure below, are identical, the first moving with speed  $v$  toward right and the second staying at rest. The wall at the extreme right is fixed and smooth. Assuming all collisions to be elastic.



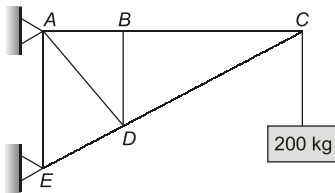
Which of the following statements are correct ?

- There are only three collisions.
  - The speed of first ball is reduced to zero finally after all collisions.
  - Only two collisions are possible.
  - The speeds of balls remain unchanged after all collisions have taken place.
- (a) 1 and 2                      (b) 3 and 4
- (c) 1 and 4                      (d) 2 and 3
- Q.24** An engine supplies a constant power  $P$  to automobile of mass  $m$  starting from rest. At an instant of time  $t$ .
- Velocity is proportional to  $\sqrt{t}$ .
  - Velocity is inversely proportion to  $\sqrt{P}$ .
  - Displacement is proportional to  $\sqrt{\frac{P}{m}}$ .
  - Displacement is proportional to  $t^{3/2}$ .
- Which of these statements are correct ?
- (a) 1, 2 and 3                      (b) 1, 3 and 4
- (c) 1, 2 and 4                      (d) 1, 2, 3 and 4

- Q.25** An engine pumps out water continuously through a hose with a velocity  $v$ . If  $m$  is the mass per unit length of water jet, the rate at which the kinetic energy is imparted to water is

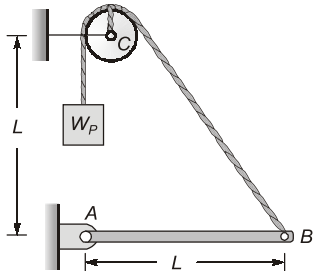
- (a)  $\frac{1}{2}mv^2$  (b)  $\frac{1}{2}mv^3$   
 (c)  $\frac{1}{2}m^2v^2$  (d)  $mv^3$

**Q.26** The figure shows a pin-jointed plane truss loaded at the point  $C$  by hanging a mass of 200 kg. The member  $BD$  of the truss is subjected to a load of



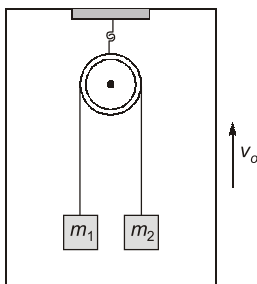
- (a) 0 (b) 981 in compression  
 (c) 1962 in tension (d) 1962 in compression

**Q.27** A uniform, heavy rod  $AB$  of length  $L$  and weight  $W$  is hinged at  $A$  and tied to a weight  $W_P$  by a string at  $B$ . The massless string passes over a frictionless pulley (of negligible dimension) at  $C$  as shown in the figure. If the rod is in equilibrium at horizontal configuration, then



- (a)  $W_P = \frac{W}{2}$  (b)  $W_P = \frac{W}{\sqrt{2}}$   
 (c)  $W_P = W$  (d)  $W_P = \sqrt{2}W$

**Q.28** Two blocks of masses  $m_1$  and  $m_2$  ( $m_1 > m_2$ ) are connected by a massless thread, that passes over a massless smooth pulley. The pulley is suspended from the ceiling of an elevator. Now the elevator moves up with uniform velocity  $v_o$ . Which of the following statements are correct?

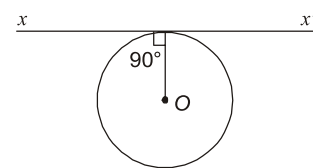


1. Magnitude of acceleration of  $m_1$  with respect to the ground is greater than  $\frac{(m_1 - m_2)}{m_1 + m_2}g$ .
  2. Magnitude of acceleration of  $m_1$  with respect to ground is equal to  $\frac{(m_1 - m_2)g}{m_1 + m_2}$ .
  3. Tension in the thread that connects  $m_1$  and  $m_2$  is equal to  $\frac{2m_1m_2g}{m_1 + m_2}$ .
  4. Tension in the thread that connects  $m_1$  and  $m_2$  is greater than  $\frac{2m_1m_2g}{m_1 + m_2}$ .
- (a) 1 and 3 (b) 2 and 3  
 (c) 2 and 4 (d) 1 and 4

**Q.29** A mass 2.4 kg is suspended from massless string of length 50 cm. Initially, the mass is at rest with the string along the vertical. Another object of mass 600 gram and moving horizontally at a speed of 50 m/s, hits the suspended body and sticks to it, then

- (a) they are unable to complete vertical circle  
 (b) they are able to complete vertical circle  
 (c) their system begins to oscillate about the original position of 2.4 kg mass  
 (d) tension in the string remains constant

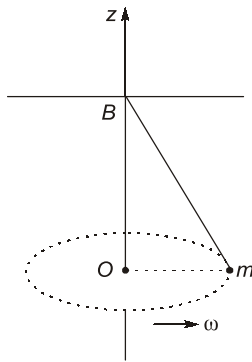
**Q.30** A thin wire of length  $L$  and uniform linear mass density  $\rho$  is bent into a circular loop with centre  $O$  as shown. The moment of inertia of the loop about the axis  $xx'$  is



- (a)  $\frac{\rho L^3}{8\pi^2}$  (b)  $\frac{\rho L^3}{16\pi^2}$   
 (c)  $\frac{5\rho L^3}{16\pi^2}$  (d)  $\frac{3\rho L^3}{8\pi^2}$

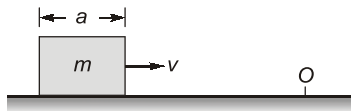
**Q.31** A small mass  $m$  is attached to a massless string whose other end is fixed at  $B$  as shown in the figure. The mass is undergoing circular motion in the  $x$ - $y$  plane with centre  $O$  and constant angular speed  $\omega$ . If the angular momentum of system, calculated about  $O$  and  $B$  are denoted by  $\vec{L}_O$  and  $\vec{L}_B$  respectively, then





- (a)  $\vec{L}_O$  and  $\vec{L}_B$  do not vary with time  
 (b)  $\vec{L}_O$  varies with time while  $\vec{L}_B$  remains constant  
 (c)  $\vec{L}_O$  remains constant while  $\vec{L}_B$  varies with time  
 (d)  $\vec{L}_O$  and  $\vec{L}_B$  both vary with time

**Q.32** A cubical block of side  $a$  is moving with velocity  $v$  on the horizontal smooth plane as shown in figure below. It hits a ridge at point  $O$ . The angular speed of the block after it hits  $O$  is

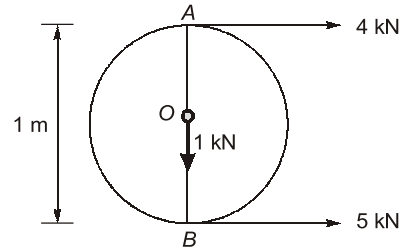


- (a)  $\frac{3v}{4a}$  (b)  $\frac{3v}{2a}$   
 (c)  $\frac{\sqrt{3}v}{\sqrt{2}a}$  (d) zero

**Q.33** The resultant of two forces  $(P + Q)$  and  $(P - Q)$  is equal to  $\sqrt{3P^2 + Q^2}$ . The forces are then inclined to each other, at the angle of  
 (a)  $30^\circ$  (b)  $60^\circ$   
 (c)  $90^\circ$  (d)  $120^\circ$

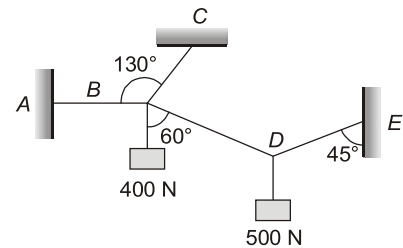
**Q.34** The displacement in meters of a point is given by equation  
 $x = 2t^2 + 5t$ ;  $y = 4.9t^2$   
 The acceleration at the end of 4<sup>th</sup> second is  
 (a)  $7.42 \text{ m/s}^2$  (b)  $10.58 \text{ m/s}^2$   
 (c)  $3.71 \text{ m/s}^2$  (d)  $11.00 \text{ m/s}^2$

**Q.35** A pulley of 1 m diameter is subjected to 4 kN and 5 kN forces at  $A$  and  $B$  respectively as shown in figure. Its own weight of 1 kN acts through the centre  $O$ . Then the resultant force is



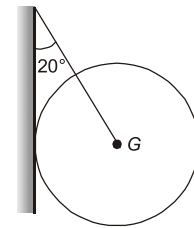
- (a) 5.055 kN (b) 7.055 kN  
 (c) 9.055 kN (d) 11.055 kN

**Q.36** A system of connected flexible cables shown in figure is supporting two loads 400 N and 500 N at points  $B$  and  $D$ . Then the tension in the segment  $BD$  will be \_\_\_\_\_ N.



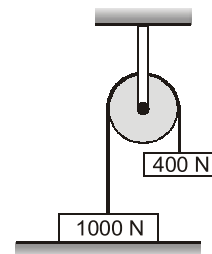
- (a) 166.02 N (b) 266.02 N  
 (c) 366.02 N (d) 466.02 N

**Q.37** A sphere weighing 300 N is tied to a smooth wall by a string as shown in figure. Determine the tension in the string \_\_\_\_\_ N.



- (a) 319.15 N (b) 519.15 N  
 (c) 719.15 N (d) 919.15 N

**Q.38** The force with which the 1000 N block press against the floor is



- (a) 400 N (b) 600 N  
 (c) 1000 N (d) 1200 N

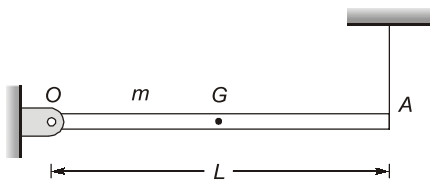
**Q.39** A particle is moving along a circular path. Equation of angular velocity is  $\omega = 12 + 9t - 3t^2$  rad/s, where  $t$  is in seconds. Maximum angular speed of particle can be

- (a) 14.75 rad/s      (b) 16.75 rad/s  
(c) 18.75 rad/s      (d) 20.75 rad/s

**Q.40** A uniform bar of mass  $m$ , length  $L$ , hinged at  $O$  and supported at  $A$  by a string as shown. Suddenly the string breaks and bar starts rotating about  $O$ . The angular acceleration of the bar is

$\frac{Kg}{L}$  then  $K$  is

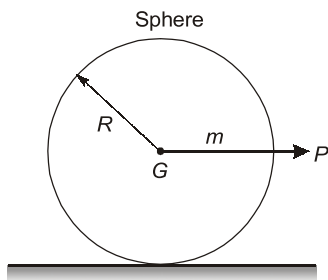
- (a) 1.5      (b) 2.5  
(c) 3.5      (d) 4.5



**Q.41** A solid sphere of mass  $m$ , radius  $R$  is pulled along a rough horizontal plane by a horizontal force  $P$  applied through centre of sphere. The

acceleration of its mass centre  $G$  is  $\frac{KP}{m}$  then  $K$  is

- (a) 0.31      (b) 0.51  
(c) 0.71      (d) 0.91



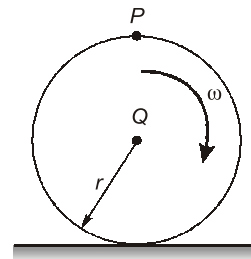
**Q.42** A block of weight  $W$  is given an initial velocity  $v_0$  along a rough horizontal plane and is brought to rest by friction in a distance  $x$ . The coefficient of friction will be

- (a)  $\mu = \frac{v_0^2}{2gx}$       (b)  $\mu = \frac{v_0^2}{4gx}$   
(c)  $\mu = \frac{v_0^2}{8gx}$       (d)  $\mu = \frac{v_0^2}{gx}$

**Q.43** The rotor of a gas turbine is rotating at a speed of 8000 rpm when the turbine is shut down. It is observed that 5 min is required for the rotor to come to rest. Assuming uniformly decelerated motion, the number of revolutions that the rotor executes before coming to rest is

- (a) 18000      (b) 125604  
(c) 2000      (d) 20000

**Q.44** A wheel of radius 0.1 m rolls without slipping on a horizontal surface shown below. The ratio of velocity of point  $P$  to velocity of point  $Q$  will be



- (a) 2      (b) 1  
(c) 0.5      (d) 2.5

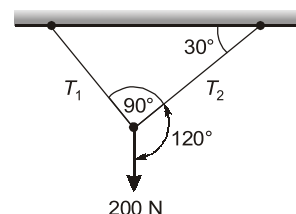
**Q.45** A hunter has a machine gun that can fire 50 g bullets with a velocity of  $150 \text{ ms}^{-1}$ . A 60 kg tiger springs at him with a velocity of  $10 \text{ ms}^{-1}$ . What will be the number of bullets the hunter fire into the tiger in order to stop him in his track?

- (a) 40      (b) 80  
(c) 160      (d) 320

**Q.46** A body of mass 10 kg is placed on a horizontal wooden plank of length 0.75 m. One end of the plank is slowly raised by keeping the other end at rest on the ground. When the other end is at a height of 0.30 m, the body begins to just slide down the plank. The coefficient of friction between body and the plank is

- (a) 0.136      (b) 0.236  
(c) 0.336      (d) 0.436

**Q.47** A weight of 200 N is supported by two metallic ropes as shown in the figure. The ratio of tensions  $T_1/T_2$  is

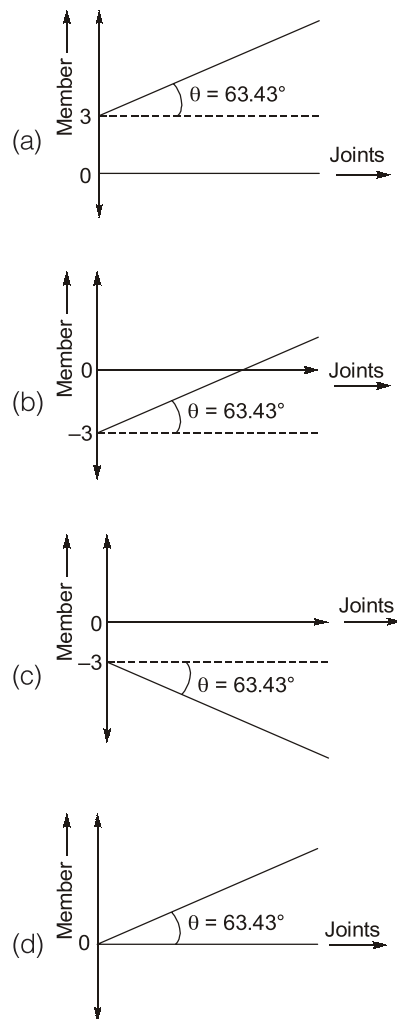


- (a) 1.732      (b) 2.732  
(c) 3.732      (d) 4.732

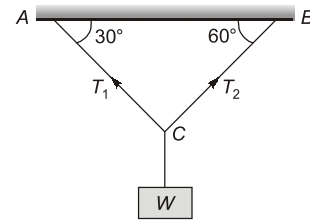
**Q.48** An object of mass  $m$  moving forward with velocity  $V$  along  $x$ -axis collides elastically with a stationary object  $Y$  of mass  $2m$  at origin. After collision, the object  $X$  moves backward along  $x$ -axis. Given that the kinetic energy of the system is conserved, speed of object  $Y$  after collision is

- (a)  $\frac{2V}{3}$
- (b)  $\frac{V}{3}$
- (c)  $\frac{V}{2}$
- (d)  $\frac{3V}{4}$

**Q.49** For a statically determinate frame, which of the following is the correct graph between number of members and number of joints?



**Q.50** A weight of 3000 N is supported by two chains  $AC$  and  $BC$  as shown.  $T_1$  and  $T_2$  are the tensions in each chain. The value of  $\frac{T_1}{T_2}$  is?

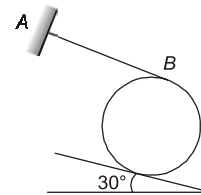


- (a) 0.216
- (b) 0.577
- (c) 0.644
- (d) 1.732

**Q.51** A thin circular ring of mass 5 kg and radius 20 cm is rotating about its axis with an angular speed 10 rad/s. Two particles having mass 0.5 kg each are now attached at diametrically opposite points. The angular speed of the ring will be

(a) 4.33 rad s<sup>-1</sup>      (b) 6.33 rad s<sup>-1</sup>  
(c) 8.33 rad s<sup>-1</sup>      (d) 10.33 rad s<sup>-1</sup>

**Q.52** A thin hoop of radius 1m and weight 500 N rests on a rough incline plane. The coefficient of friction between hoop and incline is unknown. The tension in wire  $AB$  is

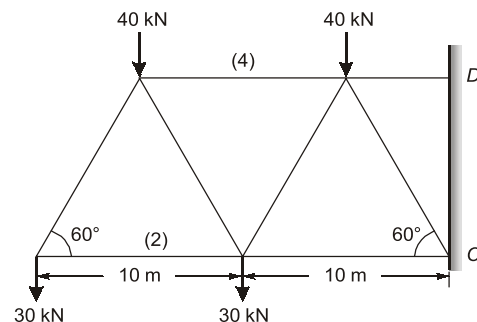


- (a) 125 N
- (b) 135 N
- (c) 145 N
- (d) 155 N

**Q.53** A small bar starts sliding down on an inclined plane making an angle 45° with the horizontal. The coefficient of friction depends on the distance  $x$  as  $\mu = 5x$ . The distance covered by the bar till it stops is

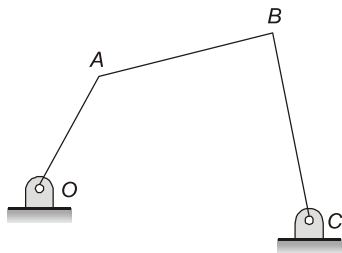
(a) 0.4 m      (b) 0.8 m  
(c) 1.6 m      (d) 3.2 m

**Q.54** For the truss shown below, the ratio of magnitudes of forces in member 4 to member 2 will be



- (a) 1.22
- (b) 2.44
- (c) 3.33
- (d) 4.33

**Q.192** The four bar mechanism shown in the figure  
(Given:  $OA = 4$  cm;  $AB = 5$  cm;  $BC = 6$  cm;  
 $OC = 8$  cm) is a



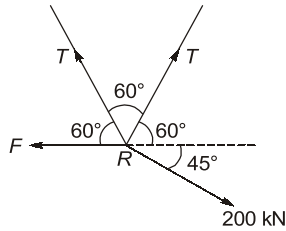
- (a) Double crank mechanism
- (b) Crank rocker mechanism
- (c) Double rocker mechanism
- (d) Single slider mechanism

■■■■

Answers								Engineering Mechanics and Theory of Machines							
1.	(c)	2.	(a)	3.	(c)	4.	(d)	5.	(b)	6.	(b)	7.	(c)	8.	(c)
9.	(c)	10.	(c)	11.	(c)	12.	(b)	13.	(d)	14.	(a)	15.	(a)	16.	(a)
17.	(d)	18.	(d)	19.	(d)	20.	(d)	21.	(b)	22.	(b)	23.	(c)	24.	(b)
25.	(b)	26.	(a)	27.	(b)	28.	(b)	29.	(b)	30.	(d)	31.	(c)	32.	(a)
33.	(b)	34.	(b)	35.	(c)	36.	(c)	37.	(a)	38.	(b)	39.	(c)	40.	(a)
41.	(c)	42.	(a)	43.	(d)	44.	(a)	45.	(b)	46.	(d)	47.	(a)	48.	(b)
49.	(b)	50.	(b)	51.	(c)	52.	(a)	53.	(a)	54.	(c)	55.	(a)	56.	(b)
57.	(a)	58.	(d)	59.	(d)	60.	(a)	61.	(b)	62.	(c)	63.	(a)	64.	(d)
65.	(d)	66.	(d)	67.	(b)	68.	(d)	69.	(b)	70.	(d)	71.	(d)	72.	(a)
73.	(a)	74.	(b)	75.	(c)	76.	(d)	77.	(d)	78.	(a)	79.	(d)	80.	(b)
81.	(b)	82.	(c)	83.	(a)	84.	(a)	85.	(a)	86.	(b)	87.	(b)	88.	(b)
89.	(a)	90.	(c)	91.	(b)	92.	(a)	93.	(d)	94.	(a)	95.	(b)	96.	(a)
97.	(a)	98.	(d)	99.	(d)	100.	(c)	101.	(d)	102.	(a)	103.	(b)	104.	(b)
105.	(d)	106.	(b)	107.	(a)	108.	(b)	109.	(a)	110.	(b)	111.	(d)	112.	(a)
113.	(d)	114.	(b)	115.	(d)	116.	(a)	117.	(b)	118.	(a)	119.	(c)	120.	(d)
121.	(b)	122.	(c)	123.	(c)	124.	(c)	125.	(a)	126.	(d)	127.	(a)	128.	(d)
129.	(a)	130.	(a)	131.	(b)	132.	(b)	133.	(b)	134.	(b)	135.	(b)	136.	(b)
137.	(c)	138.	(d)	139.	(b)	140.	(d)	141.	(d)	142.	(d)	143.	(d)	144.	(c)
145.	(c)	146.	(b)	147.	(a)	148.	(d)	149.	(c)	150.	(c)	151.	(b)	152.	(d)
153.	(b)	154.	(a)	155.	(d)	156.	(b)	157.	(a)	158.	(c)	159.	(a)	160.	(b)
161.	(c)	162.	(d)	163.	(d)	164.	(a)	165.	(a)	166.	(d)	167.	(a)	168.	(a)
169.	(a)	170.	(b)	171.	(a)	172.	(a)	173.	(a)	174.	(d)	175.	(d)	176.	(b)
177.	(c)	178.	(b)	179.	(a)	180.	(a)	181.	(a)	182.	(a)	183.	(a)	184.	(c)
185.	(d)	186.	(c)	187.	(b)	188.	(d)	189.	(b)	190.	(c)	191.	(b)	192.	(c)

### Explanations

1. (c)



Since  $PR$  and  $QR$  are identically loaded, so considering horizontal equilibrium,

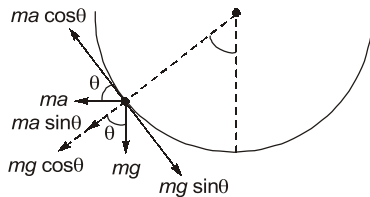
$$\begin{aligned} T \cos 60^\circ + F &= T \cos 60^\circ + 200 \cos 45^\circ \\ F &= 200 \cos 45^\circ \\ &= 200 \times \frac{1}{\sqrt{2}} = 141.4 \text{ kN} \end{aligned}$$

2. (a)

Loss in P.E. = Gain in K.E. + P.E. stored in spring

$$\begin{aligned} Mg x_{\max} &= 0 + \frac{1}{2} k x_{\max}^2 \\ x_{\max} &= \frac{2Mg}{k} \end{aligned}$$

3. (c)



For tangential equilibrium,  
 $mg \sin \theta = ma \cos \theta$

$$\Rightarrow \tan \theta = \frac{a}{g} \quad \dots(1)$$

$$\text{But } \tan \theta = \frac{dy}{dx} = \frac{d}{dx}(kx^2) = 2kx \quad \dots(2)$$

Equating equations (1) and (2), we get

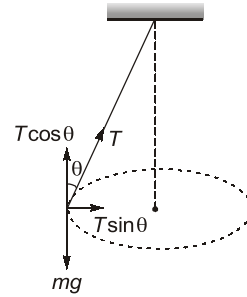
$$\frac{a}{g} = 2kx$$

$$\therefore x = \frac{a}{2gk}$$

4. (d)

The centripetal force is provided by  $T \sin \theta$

$$\begin{aligned} \therefore T \sin \theta &= m\omega^2 r \\ T \sin \theta &= m\omega^2 (L \sin \theta) \end{aligned}$$

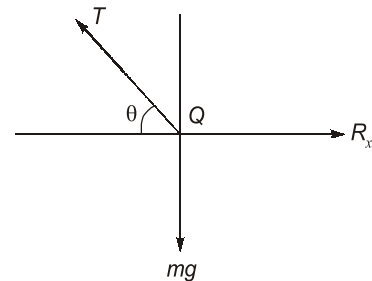


$$T = m\omega^2 L$$

$$\begin{aligned} \omega &= \sqrt{\frac{T}{mL}} = \sqrt{\frac{648}{0.25 \times 0.5}} \\ &= 72 \text{ rad/s} \end{aligned}$$

5. (b)

$$\begin{aligned} \tan \theta &= \frac{250}{250} = 1 \\ \therefore \theta &= 45^\circ \end{aligned}$$



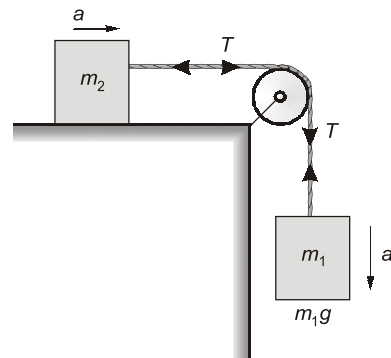
$$T \sin 45^\circ = mg$$

$$T \cos 45^\circ = R_x$$

$$T = \sqrt{2} \times 25 \times 10 = 250\sqrt{2}$$

$$R_x = 250\sqrt{2} \times \frac{1}{\sqrt{2}} = 250 \text{ N}$$

7. (c)



$$m_1 g - T = m_1 a \text{ and } T = m_2 a$$

$$\Rightarrow a = \frac{m_1 g}{m_1 + m_2}$$

**8. (c)**

$$\begin{aligned}
 U &= -\int F dx \\
 &= -\int (-kx + ax^3) dx \\
 &= \frac{kx^2}{2} - \frac{ax^4}{4}
 \end{aligned}$$

P.E. is zero when  $x = \sqrt{\frac{2k}{a}}$

and  $x = 0$

If  $x > \sqrt{\frac{2k}{a}}$

then P.E. is negative

**9. (c)**

As the body just reaches the top most point B, therefore

$$v_A = \sqrt{5gL} \text{ and } v_B = \sqrt{gL}$$

Let the point be C having angular displacement  $\theta$  at which speed becomes half of the initial value  $v_A$ .

Using the law of conservation of energy,

Energy at A = Energy at C

$$\frac{1}{2}mv_A^2 = \frac{1}{2}mv_C^2 + mgL(1 - \cos\theta)$$

$$\frac{1}{2}m(v_A^2 - v_C^2) = mgL(1 - \cos\theta)$$

$$\frac{1}{2}m\left(5gL - \frac{5gL}{4}\right) = mgL(1 - \cos\theta)$$

$$\frac{15}{8} = 1 - \cos\theta$$

$$\cos\theta = \frac{-7}{8}$$

So  $\theta$  lies between  $\frac{3\pi}{4}$  and  $\pi$

$$\text{or, } \frac{3\pi}{4} < \theta < \pi$$

**10. (c)**

They will hit at the centre of mass. Let  $r_1$  be distance of centre of mass from 12 kg and  $r_2$  be distance of centre of mass from 6 kg.

$$r_1 = \left(\frac{m_2}{m_1 + m_2}\right)r = \left(\frac{6}{12 + 6}\right) \times 90 = 30 \text{ m}$$

$$r_2 = \left(\frac{m_1}{m_1 + m_2}\right)r = \left(\frac{12}{12 + 6}\right) \times 90 = 60 \text{ m}$$

**11. (c)**

The velocity of ball A before impact,  $V_A = \sqrt{2gh}$

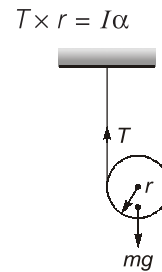
Using principle of conservation of momentum,  $m_A v_A + m_B v_B = (m_A + m_B)v$  ( $\because$  For inelastic impact,  $v_A' = v_B' = v$  and  $v_B = 0$ )

$$\therefore m \times \sqrt{2gh} + 0 = (m + 2m)v$$

$$v = \frac{m\sqrt{2gh}}{3m} = \frac{1}{3}\sqrt{2gh}$$

**12. (b)**

$$\begin{aligned}
 \frac{E_{\text{rotational}}}{E_{\text{translational}}} &= \frac{\frac{1}{2}I\omega^2}{\frac{1}{2}mv^2} \\
 &= \frac{\frac{1}{2}\left(\frac{2}{5}mR^2\right)\frac{v^2}{R^2}}{\frac{1}{2}mv^2} = \frac{2}{5}
 \end{aligned}$$

**13. (d)**

$$\text{or } \left(\frac{mr^2}{2}\right)\alpha = T \times r$$

$$\text{or } \frac{mr^2}{2} \times \frac{a}{r} = T \times r$$

$$\therefore T = \frac{ma}{2}$$

Balancing the forces,

$$mg - T = ma$$

$$T = mg - ma$$

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

$$\therefore a = \frac{2g}{3}$$

Let the velocity of the cylinder after it has moved through a distance  $h$ , be  $v$ ,

$$\Rightarrow v^2 - u^2 = 2aS$$

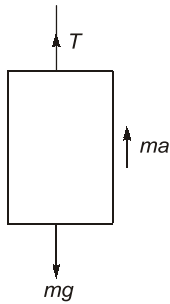
$$v^2 = 2ah \quad (\because u = 0 \text{ and } s = h)$$

$$v^2 = 2 \times \frac{2g}{3} h$$

$$v = \sqrt{\frac{4gh}{3}}$$

**14. (a)**

For uniform acceleration,



$$v = at$$

$$10 = a \times 2$$

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

$$T - mg = ma$$

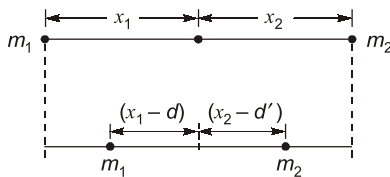
$$T = mg + ma = mg \left( 1 + \frac{a}{g} \right)$$

$$= 100 \times 10^3 \left( 1 + \frac{5}{10} \right)$$

$$= 150 \times 10^3 \text{ N} = 150 \text{ kN}$$

**16. (a)**

Initially,



$$0 = \frac{m_1(-x_1) + m_2x_2}{m_1 + m_2}$$

$$m_1x_1 = m_2x_2$$

Finally,

$$0 = \frac{-m_1(x_1 - d) + m_2(x_2 - d')}{m_1 + m_2}$$

$$0 = -m_1x_1 + m_1d + m_2x_2 - m_2d'$$

$$0 = m_1d - m_2d'$$

$$d' = \frac{m_1d}{m_2}$$

**17. (d)**

We have  $a = \frac{g \sin \theta}{1 + \frac{k^2}{R^2}}$

For cylinder A, radius of gyration is more than that for cylinder B.

$$\therefore a_A < a_B$$

$$v_A < v_B$$

(at the bottom)

$$\Rightarrow (\text{K.E.})_A < (\text{K.E.})_B$$

and  $\omega_A R < \omega_B R$

or  $\omega_A < \omega_B$

**18. (d)**

Angular momentum,

$$L = I\omega$$

$$L = (mk^2)\omega$$

$$\therefore k^2 = \frac{L}{m\omega}$$

or  $k = \sqrt{\frac{L}{m\omega}} = \sqrt{\frac{7.2}{1.5 \times 0.3}} = 4 \text{ m}$

**19. (d)**

To determine  $v$ , following principles are used.

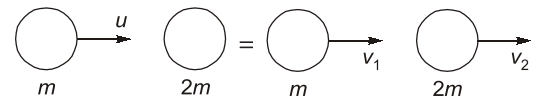
- (i) Conservation of angular momentum.
- (ii) Conservation of energy.

**20. (d)**

Let the masses of five balls be  $m, 2m, 4m, 8m$  and  $16m$ .

For collision between Ist and IInd ball:

$$mu + 0 = mv_1 + 2mv_2 \quad \dots(1)$$



also  $e = \frac{v_2 - v_1}{u} = \frac{2}{3}$

$$\therefore v_2 - v_1 = \frac{2}{3}u \quad \dots(2)$$

Adding equations (1) and (2), we get

$$v_2 = \frac{5}{9}u$$

Proceeding in the same way, the velocity of the fifth ball after collision will be

$$v_5 = \left( \frac{5}{9} \right)^4 u$$

**21. (b)**Loss in P.E. = (Work)<sub>friction</sub> + K.E. of system

$$mgh = (\text{Work})_{\text{friction}} + \frac{1}{2}(M+m)v^2$$

$$mgh = (\text{Work})_{\text{friction}} + \frac{1}{2}(M+m)\left(\frac{mv}{m+M}\right)^2$$

$$(\because v = \sqrt{2gh})$$

$$mgh = (\text{Work})_{\text{friction}} + \frac{1}{2} \frac{m^2 v^2}{(m+M)}$$

$$mgh = (\text{Work})_{\text{friction}} + \frac{1}{2} \frac{m^2 (2gh)}{(m+M)}$$

$$\therefore (\text{Work})_{\text{friction}} = mgh - \frac{m^2 gh}{(m+M)}$$

$$= mgh \left[ 1 - \frac{m}{(m+M)} \right]$$

$$= \frac{mM}{(M+m)} gh$$

**22. (b)**

A. 
$$V_{CM} = \frac{m_1 v_1 + m_2 v_2}{m_1 + m_2} = \frac{2 \times 2 + 0}{2 + 2}$$

$$= 1 \text{ m/s (1 S.I. unit)}$$

B. Using the law of conservation of momentum,

$$m_1 u_1 + m_2 u_2 = (m_1 + m_2) v$$

$$2 \times 2 + 2 \times 0 = (2 + 2) v$$

$$v = 1 \text{ m/s (i.e. 1 SI unit)}$$

C. Using energy conservation,

$$\frac{1}{2} m u^2 + 0 = \frac{1}{2} (m_1 + m_2) v^2 + \frac{1}{2} k x^2$$

$$\frac{1}{2} \times 2 \times (2)^2 + 0 = \frac{1}{2} (2 + 2) \times 1^2 + \frac{1}{2} \times 16 x^2$$

$$4 = 2 + 8x^2$$

$$x^2 = \frac{1}{4}$$

$$\Rightarrow x = 0.5 \text{ m (i.e. 0.5 S.I. unit)}$$

D. 
$$U = \frac{1}{2} k x^2 = \frac{1}{2} (16) (0.5)^2$$

$$= 2 \text{ J (i.e. 2 S.I. unit)}$$

**23. (c)**

Just before the first collision, ball A comes to rest and ball B moves with velocity  $v$ . Now, the ball B collides with the vertical wall and rebounds with

the same speed  $v$ . When ball B collides with ball A, the ball B comes to rest and ball A moves with velocity  $v$ . So, statements 1 and 4 are correct.

**24. (b)**

$$\text{Power} = P \quad (\text{Constant})$$

$$F_V = P$$

$$\left( m \frac{dv}{dt} \right) v = P$$

$$\int V dv = \frac{P}{m} \int dt$$

$$\frac{v^2}{2} = \frac{P}{m} t$$

$$v = \sqrt{\frac{2Pt}{m}}$$

$$\Rightarrow v \propto \sqrt{P}$$

$$\propto \sqrt{t}$$

Now, 
$$v = \frac{dx}{dt} = \sqrt{\frac{2P}{m}} t^{1/2}$$

$$\int dx = \sqrt{\frac{2P}{m}} \int t^{1/2} dt$$

$$x = \sqrt{\frac{2P}{m}} \left( \frac{t^{3/2}}{3/2} \right) = \sqrt{\frac{8P}{9m}} t^{3/2}$$

$$\Rightarrow x \propto t^{3/2}$$

$$\propto \sqrt{\frac{P}{m}}$$

So, statements 1, 3 and 4 are correct.

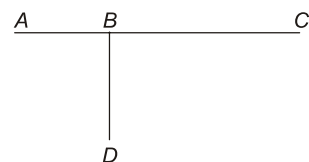
**25. (b)**

$$m = \frac{\text{mass}}{\text{length}} = \frac{dM}{dx}$$

$$\text{K.E.} = \frac{1}{2} M v^2$$

$$\frac{d}{dt}(\text{K.E.}) = \frac{1}{2} \left( \frac{dM}{dt} \right) v^2 = \frac{1}{2} \left( \frac{dM}{dx} \frac{dx}{dt} \right) v^2$$

$$= \frac{1}{2} (m \cdot v) v^2 = \frac{1}{2} m v^3$$

**26. (a)**



Considering joint  $B$  as shown in the figure above, we have force balance in y-direction, i.e.

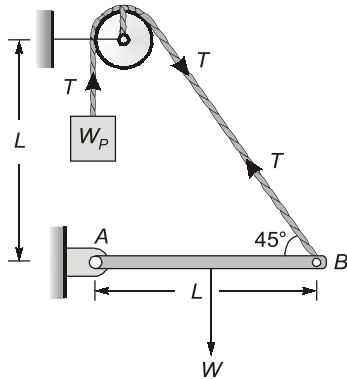
$$\Sigma F_y = 0$$

$\therefore$  Force in the member  $BD = 0$

**27. (b)**

As mass  $W_P$  is in equilibrium,

$$W_P = T$$



For equilibrium of rod,

$$\Sigma M_A = 0$$

$$T \sin 45^\circ \times L = W \times \frac{L}{2}$$

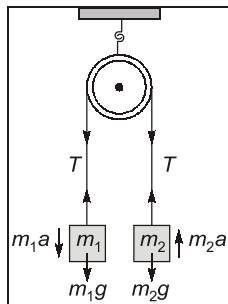
$$\Rightarrow T \times \frac{L}{\sqrt{2}} = W \times \frac{L}{2}$$

$$T = \frac{W}{2} \times \sqrt{2} = \frac{W}{\sqrt{2}}$$

$$\therefore W_P = \frac{W}{\sqrt{2}}$$

**28. (b)**

Since the lift moves with uniform velocity so the acceleration of the lift is zero.



$\therefore$  For body  $m_1$ ,

$$m_1 g - T = m_2 a \quad \dots(1)$$

Similarly, for body  $m_2$ ,

$$T - m_2 g = m_2 a \quad \dots(2)$$

From (1)

$$\Rightarrow T = m_1 g - m_1 a$$

Substituting the value of  $T$  in equation (2), we get

$$m_1 g - m_1 a = m_2 g + m_2 a$$

$$(m_1 - m_2)g = (m_1 + m_2)a$$

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

and

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

$$= \frac{2m_1 m_2 g}{m_1 + m_2}$$

**29. (b)**

The velocity at the lowest point required to complete vertical circle is

$$V_L = \sqrt{5gL} = \sqrt{5 \times 10 \times 0.50} = 5 \text{ m/s}$$

Using the law of conservation of linear momentum,

$$\text{We have } m_1 u_1 + m_2 u_2 = (m_1 + m_2)v$$

$$2.4 \times 0 + 0.6 \times 50 = (2.4 + 0.6)v$$

$$v = \frac{30}{3} = 10 \text{ m/s}$$

which is greater than  $v_L = \sqrt{5gL}$ , hence the system will complete vertical circle.

**30. (d)**

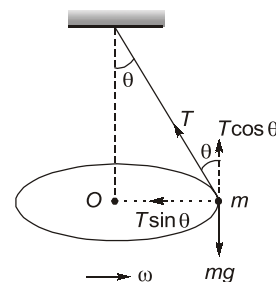
$$I_{xx}' = I + Mx^2$$

$$= \frac{1}{2}MR^2 + MR^2 = \frac{3}{2}MR^2$$

$$= \frac{3}{2}(\rho L) \left( \frac{L}{2\pi} \right)^2 = \frac{3\rho L^3}{8\pi^2}$$

**31. (c)**

Torque due to tension  $T$  about point  $B$  is zero while torque due to weight  $mg$  is non-zero. Hence,  $L_B$  will change with time. Torque due to  $T \cos \theta$  and  $mg$  about point  $O$  will cancel each other. Also, torque to  $T \sin \theta$  about point  $O$  is zero. Therefore,  $L_O$  will remain constant.



**32. (a)**

Let  $I_o$  be the M.I. of the cube about point  $O$  when the cube hits it. Using the law of conservation of angular momentum,

$$mv\left(\frac{a}{2}\right) = [I_{C.M.} + mx^2]\omega$$

$$\frac{mva}{2} = \left[ \frac{ma^2}{6} + m\left(\frac{a}{\sqrt{2}}\right)^2 \right] \omega$$

[Cube will rotate with half of diagonal as circle]

$$\Rightarrow \omega = \frac{3v}{4a}$$

**33. (b)**

$$\begin{aligned} (\sqrt{3P^2 + Q^2})^2 &= \{(P+Q)^2 + (P-Q)^2 \\ &\quad + 2(P+Q)(P-Q)\cos\theta\} \\ 3P^2 + Q^2 &= 2(P^2 + Q^2) + 2(P^2 - Q^2)\cos\theta \\ \therefore P^2 - Q^2 &= 2(P^2 - Q^2)\cos\theta \end{aligned}$$

$$\cos\theta = \frac{1}{2}$$

$$(\text{angle}) \quad \theta = 60^\circ$$

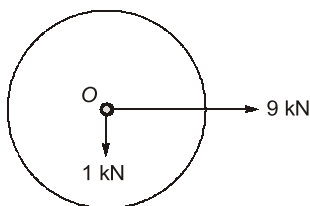
**34. (b)**

$$\text{displacement } x = 2t^2 + 5t \quad y = 4.9t^2$$

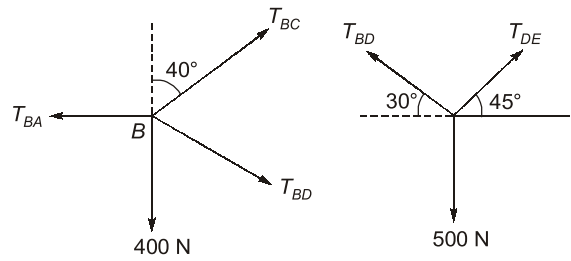
$$\text{Velocity } V_x = \frac{\partial x}{\partial t} = 4t + 5; \quad V_y = \frac{\partial y}{\partial t} = 9.8t$$

$$\text{acceleration } a_x = \frac{\partial^2 x}{\partial t^2} = 4; \quad a_y = \frac{\partial^2 y}{\partial t^2} = 9.8$$

$$\begin{aligned} \text{Total acceleration } (a) &= \sqrt{a_x^2 + a_y^2} = \sqrt{4^2 + 9.8^2} \\ &= 10.58 \text{ m/s}^2 \end{aligned}$$

**35. (c)**

$$\begin{aligned} \text{Resultant force} &= \sqrt{1+81} = \sqrt{82} \\ &= 9.055 \text{ kN} \end{aligned}$$

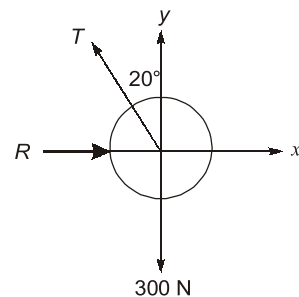
**36. (c)****Figure (a)****Figure (b)**

From figure (b)

$$\frac{T_{BD}}{\sin(90^\circ + 45^\circ)} = \frac{T_{DE}}{\sin(90^\circ + 30^\circ)}$$

$$= \frac{500}{\sin(180^\circ - 30^\circ - 45^\circ)}$$

$$T_{BD} = \frac{500 \sin(135^\circ)}{\sin(105^\circ)} = 366.02 \text{ N}$$

**37. (a)**

In  $xy$  direction

$$-T \sin 20^\circ i + T \cos 20^\circ j + Ri - 300j = 0$$

$$(R - T \sin 20^\circ)i + (0.947 - 300)j = 0$$

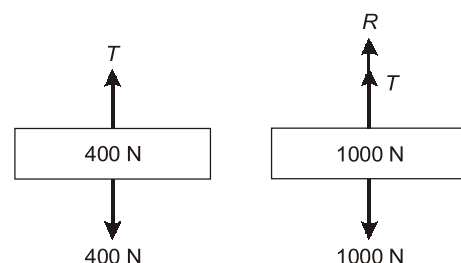
$$\text{then } R - T \sin 20^\circ = 0$$

$$0.94 T - 300 = 0$$

$$(\text{Tension}) T = \frac{300}{0.94} = 319.15 \text{ N}$$

**38. (b)**

Drawing free diagram of blocks, we have,



$$T = 400 \text{ N}$$

$$T + R = 1000$$

$$\therefore 400 + R = 1000$$

$$R = 600 \text{ N}$$

This is the reaction from the ground and it is the same force with which the 1000 N block press against the floor.

**39. (c)**

$$\omega = (12 + 9t - 3t^2)$$

$$\frac{d\omega}{dt} = 9 - 6t = 0, t = 1.5 \text{ s}$$

$$\begin{aligned}\omega_{\max} &= 12 + 9 \times 1.5 - 3 \times 1.5^2 \\ &= 12 + 13.5 - 6.75 \\ &= 18.75 \text{ rad/s}\end{aligned}$$

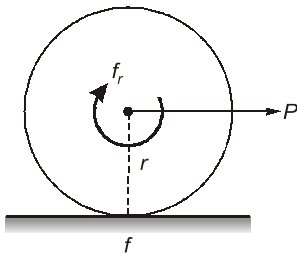
**40. (a)**

Torque,  $T = mg \times \frac{L}{2}$

$$I_0 = \frac{mL^2}{3}$$

$$\alpha = \frac{T}{I_0} = \frac{mgL}{2} \times \frac{3}{mL^2} = \frac{1.5g}{L}$$

**41. (c)**



$$P - f = ma_{cm} \text{ — 2nd law} \quad \dots(1)$$

$$[\text{Torque}]_{cm} = I_{cm} \alpha$$

$$fr = I \alpha$$

$$f = \frac{I \alpha}{r} \quad \dots(2)$$

from (1) and (2)

$$P - \frac{I \alpha}{r} = ma_{cm}$$

$$P - \frac{2}{5} \frac{mr^2 \alpha}{r} = ma_{cm}$$

$$P - \frac{2}{5} mr \alpha = ma_{cm}$$

For rolling motion  $a_{cm} = r \alpha$

$$P - \frac{2}{5} ma_{cm} = ma_{cm}$$

$$\Rightarrow P = 1.4 ma_{cm}$$

$$\Rightarrow a_{cm} = 0.71 \frac{P}{m}$$

$$\Rightarrow K = 0.71$$

**42. (a)**

Acceleration of block is given by,

$$\therefore a = \frac{-\mu W}{m}$$

$$\therefore \frac{v dv}{dx} = \frac{-\mu W}{m}$$

$$\therefore v dv = \frac{-\mu W}{m} dx$$

On integrating

$$\left[ \frac{v^2}{2} \right]_{v_0}^0 = \frac{-\mu W}{m} [dx]_0^x$$

$$0 - \frac{v_0^2}{2} = \frac{-\mu W}{m} \times x$$

$$\Rightarrow \mu = \frac{mv_0^2}{2mx} = \mu = \frac{v_0^2}{2gx}$$

or

$$v^2 = u^2 + 2aS$$

$$0 = v_0^2 + 2(-ug)x$$

$$u = \frac{v_0^2}{2gx}$$

**43. (d)**

$$\omega_0 = 8000 \text{ rpm} = 837.33 \text{ rad/s}$$

$$t = 5 \text{ min} = 300 \text{ s}$$

$$\theta = \omega_0 t + \frac{1}{2} \alpha t^2$$

$$\alpha =$$

$$\frac{\omega - \omega_0}{t} = -\frac{837.33}{300} = -2.791 \text{ rad/s}^2$$

$$\begin{aligned}\theta &= 837.33 \times 300 - 0.5 \times 2.791 \times (300)^2 \\ &= 125604 \text{ rad}\end{aligned}$$

$$\therefore \text{Number of revolutions} = \frac{\theta}{2\pi} = 19990 \simeq 20000$$

**44. (a)**

Let  $\omega$  be the angular velocity of disc

$$V_Q = r\omega$$

$$V_P = r\omega + r\omega = 2r\omega$$

$$\therefore \frac{V_P}{V_Q} = 2$$

**45. (b)**

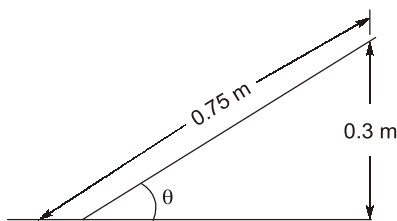
To stop the tiger in his track, momentum of the tiger should be balanced by momentum of bullets.

If the number of bullets are  $n$

Then  $MV = n(mv)$

$$\Rightarrow 60 \times 10 = n \times \frac{50}{1000} \times 150$$

$$\Rightarrow n = 80 \text{ bullets}$$

**46. (d)**

Coefficient of friction =  $\mu$   
 $\mu = \tan \theta$

$$\text{From figure, } \sin \theta = \frac{0.3}{0.75} = 0.4$$

$$\Rightarrow \theta = \sin^{-1}(0.4)$$

$$\therefore \theta = 23.57^\circ$$

$$\mu = \tan \theta$$

$$\tan 23.57^\circ = 0.436$$

$$\text{or, } mg \sin \theta = (f_s)_{\max} = \mu N$$

$$N = mg \cos \theta$$

$$\tan \theta = \mu$$

**47. (a)**

Using Lami's theorem,

$$\frac{T_1}{\sin 120^\circ} = \frac{T_2}{\sin(360 - (90 + 120))}$$

$$\therefore \frac{T_1}{T_2} = \frac{\sin 120^\circ}{\sin 150^\circ} = 1.732$$

**48. (b)**

Let  $V'$  and  $V''$  be the speed of Y and X respectively after collision.

Applying conservation of momentum,

$$mV = 2mV' - mV'' \quad \dots(a)$$

Applying conservation of kinetic energy,

$$\frac{1}{2}mV^2 = \frac{1}{2} \times 2mV'^2 + \frac{1}{2} \times mV''^2 \quad \dots(b)$$

Solving (a) and (b),

$$V' = 2V''$$

$$V = 3V''$$

$$\Rightarrow V'' = \frac{V}{3}$$

$$\Rightarrow V' = \frac{2V}{3}$$

**49. (b)**

For a statically determinate frame,

We know,  $m = 2j - 3$

Where,  $m$  = Number of members

$j$  = Number of joints

On comparing with,

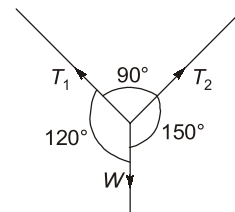
$$y = mx + c$$

$$c = -3; m = \tan \theta = 2$$

$$\therefore \theta = 63.43^\circ$$

**50. (b)**

Applying Lami's Theorem,



$$\frac{T_1}{\sin 150^\circ} = \frac{T_2}{\sin 120^\circ} = \frac{W}{\sin 90^\circ}$$

$$\therefore \frac{T_1}{T_2} = \frac{\sin 150^\circ}{\sin 120^\circ}$$

$$\therefore \frac{T_1}{T_2} = 0.577$$

**51. (c)**

Since no external torque has acted, angular momentum will be conserved.

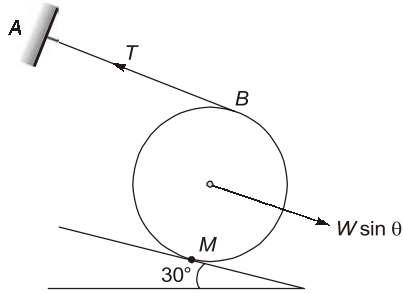
Applying conservation of momentum,

$$\therefore I\omega = I'\omega'$$

$$MR^2 \times \omega = (MR^2 + 2mR^2)\omega'$$

$$5 \times (0.2)^2 \times 10 = [5 \times (0.2)^2 + 2 \times 0.5 \times (0.2)^2]\omega'$$

$$\Rightarrow \omega' = 8.333 \text{ rad s}^{-1}$$

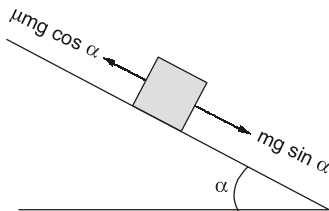
**52. (a)**

Taking moment about M,

$$T \times 2 = W \sin \theta \times 1$$

$$T \times 2 = 500 \times \frac{1}{2} \times 1$$

$$T = \frac{250}{2} = 125 \text{ N}$$

**53. (a)**Here,  $\alpha = 45^\circ$ 

We have:  $a = \frac{dV}{dt} \Rightarrow a = \frac{dV}{dx} \times \frac{dx}{dt}$

$$\therefore a = \frac{dV}{dx} \times V$$

Also,  $a = \frac{mg \sin \alpha - \mu mg \cos \alpha}{m}$

$$a = g[\sin \alpha - \mu \cos \alpha]$$

$$\therefore g[\sin \alpha - \mu \cos \alpha] = \frac{dV}{dx} \times V$$

$$\therefore g[\sin \alpha \cdot dx - 5 \cos \alpha \cdot dx] = V \cdot dV$$

On integrating,

$$g \left[ \sin \alpha \cdot x - 5 \cos \alpha \times \frac{x^2}{2} \right] = \left[ \frac{V^2}{2} \right]_0^0$$

$$g \left[ \sin \alpha \cdot x - 5 \cos \alpha \times \frac{x^2}{2} \right] = 0$$

$$\Rightarrow \sin \alpha \cdot x = 5 \cos \alpha \times \frac{x^2}{2}$$

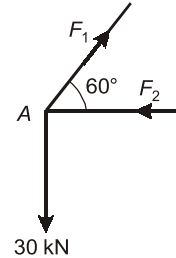
$$x = \frac{2 \tan \alpha}{5}$$

$$\Rightarrow \frac{2 \tan 45^\circ}{5} = 0.4 \text{ m}$$

**54. (c)**

Consider the free body diagram of joint A with the direction of forces assumed as shown.

Joint A,



Equations of equilibrium are:

$$\sum F_x = 0$$

$$F_1 \cos 60^\circ - F_2 = 0$$

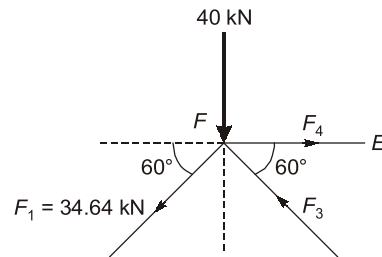
Also,  $\sum F_y = 0$

$$F_1 \sin 60^\circ - 30 = 0$$

$$\therefore F_1 = 34.64 \text{ kN}$$

$$F_2 = F_1 \cos 60^\circ = 34.64 \times 0.5 = 17.32 \text{ kN (compression)}$$

Joint F,



$$\sum F_x = 0$$

$$F_4 - F_3 \cos 60^\circ - 34.64 \cos 60^\circ = 0$$

$$F_4 = 0.5 F_3 + 17.32$$

$$\sum F_y = 0$$

$$F_3 \sin 60^\circ - 34.64 \sin 60^\circ - 40 = 0$$

$$F_3 = 80.81 \text{ kN}$$

$$F_4 = 0.5 \times 80.81 + 17.32 = 57.72 \text{ (tension)}$$

$$\therefore \frac{F_4}{F_2} = 3.332$$

**55. (a)**Acceleration along inclined plane is  $g \sin \theta$ Vertical component of acceleration is  $g \sin^2 \theta$ 

$$a_{Ay} = g \sin^2 60^\circ$$

$$a_{By} = g \sin^2 30^\circ$$

$$\therefore a_{ry} = g \left( \frac{3}{4} - \frac{1}{4} \right) = \frac{g}{2} = 4.9 \text{ m/s}^2$$

in vertically downward direction.