[SINGLE CORRECT CHOICE TYPE]

Q.1 A table has heavy circular top of radius 1 m and mass 20 kg. It has four light legs of length 1 m fixed symmetrically on its circumference. What is maximum area of the table top over which any weight may be placed without toppling it

(A) 1 m^2 (B) πm^2 (C) 2 m^2 (D) 2 π m^2

Q.2 In the Q. No.1 what is the maximum mass that may placed anywhere on the table without toppling the table

(A) 24 kg (B) 12 kg (C) 48 kg (D) 36 kg

Q.3 The velocity of the topmost and bottom most points of a disc are v_1 and v_2 in the same direction. The radius of the disc is R. Find the velocity of a point which is R/2 above the centre

(A) $\frac{3(v_1 + v_2)}{4}$ (B) $\frac{3v_1 + v_2}{4}$ (C) $\frac{v_1 + v_2}{4}$ (D) $\frac{v_1 + 3v_2}{4}$

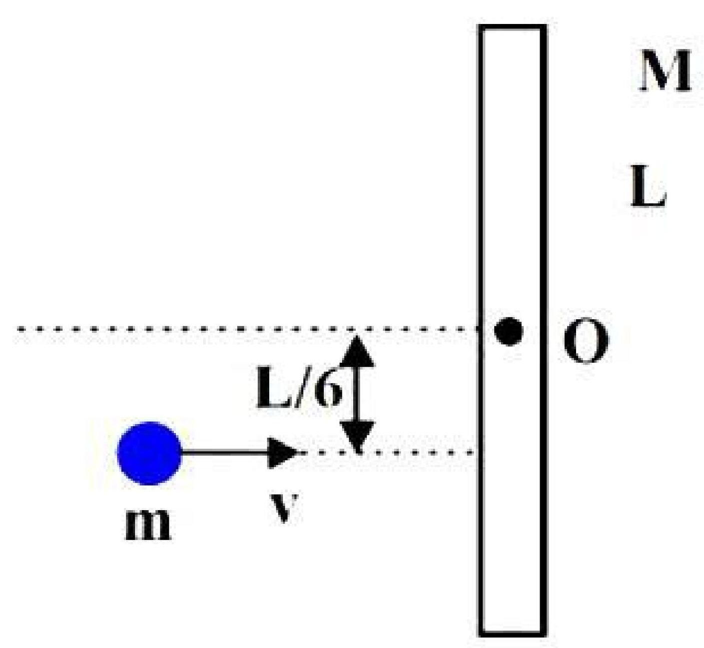
Q.4 A ring moves from top to the bottom of an inclined frictionless plane in time t_1 and takes time t_2 when it rolls down on a similar rough plane without slipping, then the ratio $\frac{t_1}{t_2}$ is

(A) $\frac{\sqrt{3}}{\sqrt{2}}$ (B) $\frac{\sqrt{2}}{\sqrt{3}}$ (C) $\frac{\sqrt{1}}{\sqrt{2}}$ (D) $\frac{\sqrt{2}}{\sqrt{1}}$

Q.5 A thick walled hollow sphere has outer radius R. It rolls down an incline without slipping and its speed at bottom is v_0. Now the incline is waxed so that the friction is absent. The sphere is observed to slide down without rolling and the speed is now $\left(\frac{5v_o}{4}\right)$. The radius gyration of the hollow sphere about the axis through its centre is

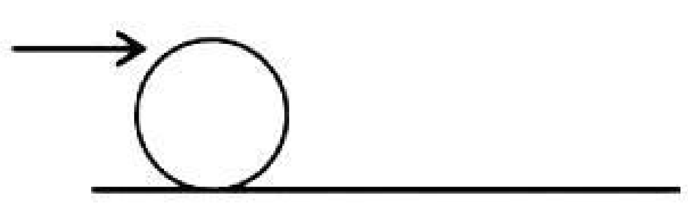
(A) $\frac{3}{4}R$ (B) $\frac{\sqrt{3}}{4}R$ (C) $\frac{2}{3}R$ (D) None of these

Q.6 A uniform rod of mass M and length L lies on a smooth horizontal surface. A particle of mass m moving at a speed v perpendicular to the length of the rod strikes it at a distance $\frac{L}{6}$ from the centre and comes to rest, after collision. The angular velocity of the rod about its centre just after the collision is **[3]**



(A) $\frac{mv}{ML}$ (B) $\frac{2mv}{ML}$ (C) $\frac{3mv}{ML}$ (D) $\frac{mv}{2ML}$

Q.7 A force F is applied at the top of a disc of mass M and radius R placed on a rough horizontal surface as shown in figure. Friction is sufficient to prevent slipping. The friction force acting on the disc is



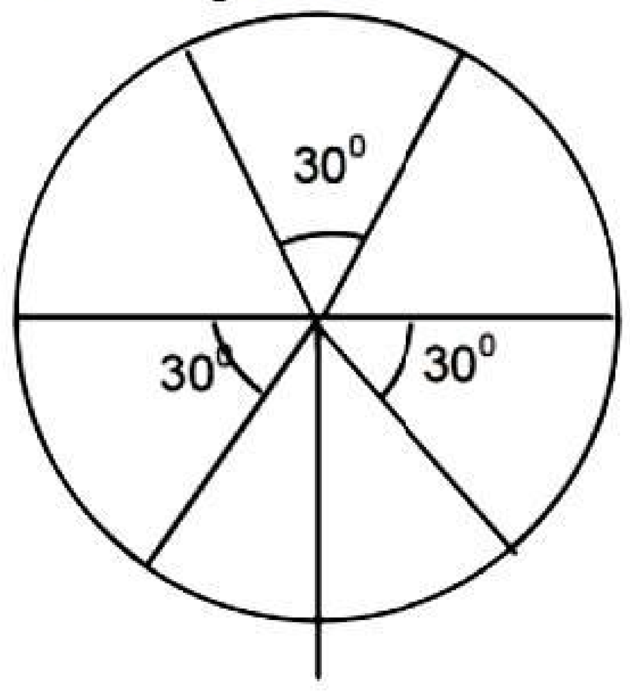
(A) F/3 towards left (B) F/3 towards right

(C) F/2 towards left (D) F/2 towards right

Q.8 A thin circular ring of mass M and radius r is rotating about its axis with a constant angular velocity ω. Two objects each of mass m are attached gently to the opposite ends of the diameter of the ring. The ring now rotates with an angular velocity

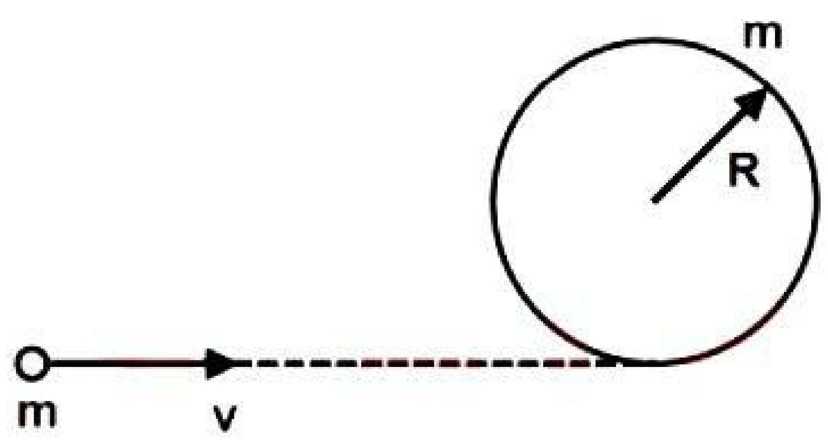
(A) $\frac{\omega m}{M+m}$ (B) $\frac{(M-2m)\omega}{(M+2m)}$ (C) $\frac{M\omega}{(M+2m)}$ (D) $\frac{(M+2m)\omega}{M}$

Q.9 The value of M.I. of shadow portions of a plate about the axis passing through its C.M. and perpendicular to the plane of the plate, if total mass of plate is M and its radius is R, is



(A) $\frac{MR^2}{4}$ (B) $\frac{MR^2}{8}$ (C) $\frac{MR^2}{6}$ (D) none of these

Q.10 A circular ring of mass m and radius R rests flat on a horizontal frictionless surface. A bullet, also of mass m, and moving with a velocity v, strikes the ring and gets embedded in its periphery. The thickness of the ring is much smaller than R. The angular velocity with which the system rotates after the bullet strikes the hoop is



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

Q.11 The M.I. of a disc of mass M and radius R about an axis, which is tangential to the circumference of the disc and parallel to its diameter is

(A) $3MR^2/2$ (B) $2MR^2/3$ (C) $5MR^2/4$ (D) $4MR^2/5$

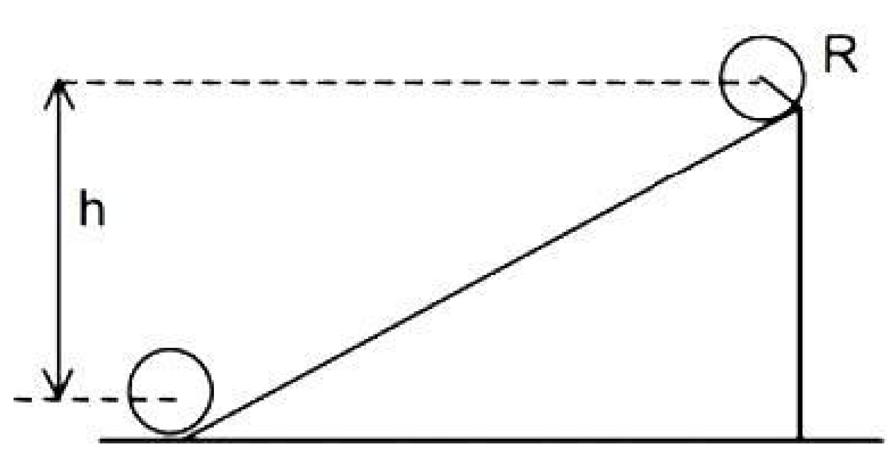
Q.12 The centre of a wheel rolling on a plane surface moves with a speed V_0. A particle on the rim of the wheel at the same level as the centre will be moving at speed

(A) Zero (B) V_0 (C) $\sqrt{2}\ V_0$ (D) $2\ V_0$

Q.13 A rod of length L, whose lower end is fixed on the horizontal plane, starts to topple from the vertical position. The velocity of the upper end when it hits the ground is

(A) $\sqrt{gL}$ (B) $\sqrt{5gL}$ (C) $\sqrt{3gL}$ (D) $3\sqrt{gL}$

Q.14 A hoop of mass M and radius r is at rest at the top of an inclined plane as shown in the figure. The hoop rolls down the plane without slipping. When the hoop reaches the bottom, its angular momentum around its centre of mass is

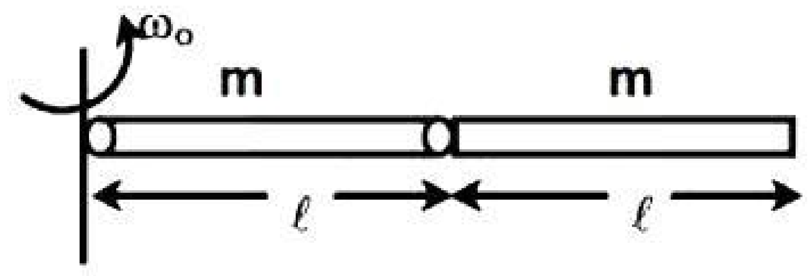


(A) $MR\sqrt{gh}$ (B) $\frac{1}{2}MR\sqrt{gh}$ (C) $M\sqrt{gh}$ (D) Mgh

Q.15 A disc of mass M and radius R is pivoted about a horizontal axis through its centre and a small body of the same mass M is attached to the rim of the disc. If the disc is released from rest with small body at the end of a horizontal radius, the angular speed when the small body is at the bottom is

(A) $\sqrt{4g/3R}$ (B) $\sqrt{3g/4R}$ (C) $\sqrt{g/2R}$ (D) $\sqrt{g/4R}$

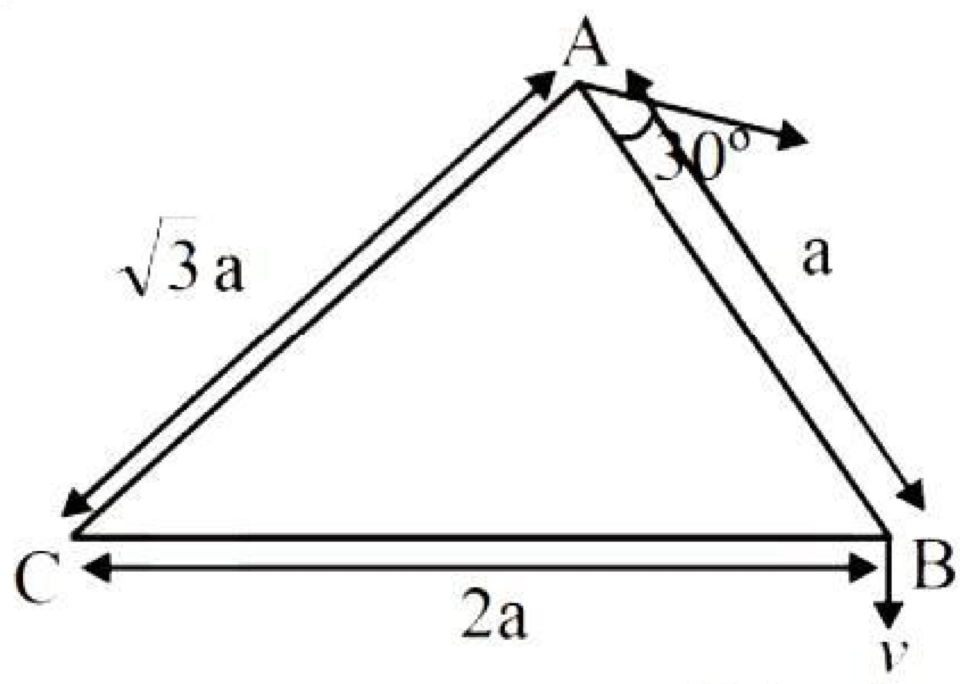
Q.16 A rod of mass m and length l fits into a hollow tube of same length and mass. The tube is rotated with an angular velocity ω_0 and the rod slips through the rough hollow surface. The angular velocity of the rod as it slips out of the tube is



(A) $\omega_0/2$ (B) $\omega_0/4$ (C) $w_0/16$ (D) $w_0/7$

[MULTIPLE CORRECT CHOICE TYPE]

Q.17 A triangular block is moving in its own plane such that at an instant speed of corner A and B are v each, as shown in figure. Then

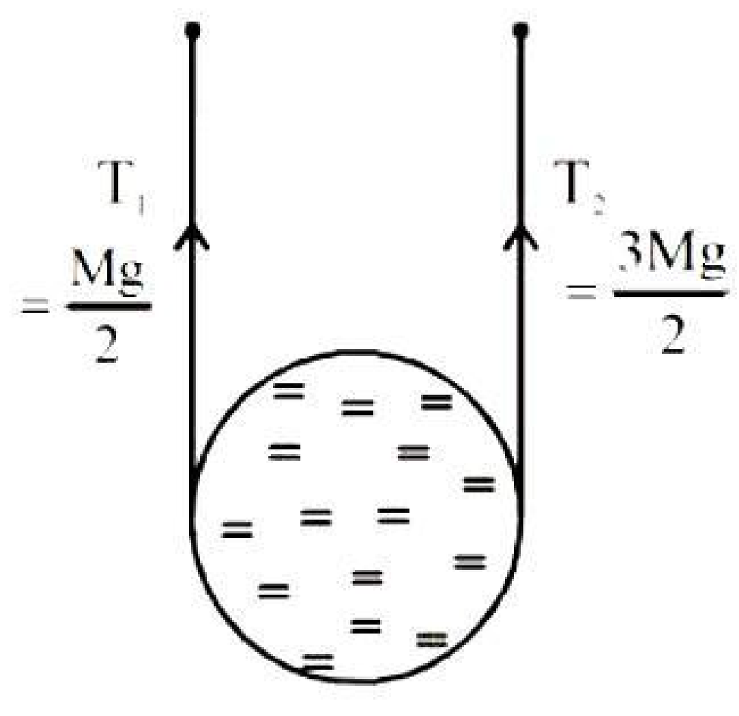


(A) velocity of end C is zero
(B) velocity of end C is v upwards
(C) velocity of mid-point of side BC is zero
(D) velocity of mid-point of side AC is along AC

Q.18 Three solid cylinders A, B and C each of mass m and radius R are allowed to roll down on three inclined planes A', B' and C' respectively (each of inclination θ) such that for A' and A coefficient of friction is zero, for B' and B coefficient of friction is greater than zero but less than $\frac{\tan\theta}{3}$ and for C' and C coefficient of friction is more than $\frac{\tan\theta}{3}$. On reaching bottom of the inclined plane

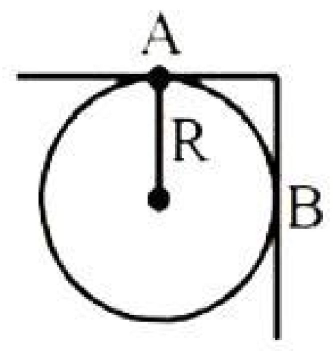
(A) C has maximum angular speed
(B) B has minimum total kinetic energy
(C) A takes minimum time to reach the bottom
(D) B has minimum translational kinetic energy

Q.19 A uniform disc of mass M and radius R is lifted using a string as shown in the figure. Then,



(A) Its linear acceleration is g upward
(B) Its linear acceleration is g downward
(C) Its angular acceleration is $\frac{2g}{R}$
(D) Its rate of change of angular momentum is MgR

Q.20 A rod bent at right angle along its centre line, is placed on a rough horizontal fixed cylinder of radius R as shown in figure. Mass of rod is 2 m and rod is in equilibrium. Assume that friction force on rod at A and B are equal in magnitde.



(A) Normal force applied by cylinder on rod at A is 3mg/2.
(B) Normal force applied by cylinder on rod at B must be zero.
(C) Friction force acting on rod at B is upward.
(D) Normal force applied by cylinder on rod at A is mg.

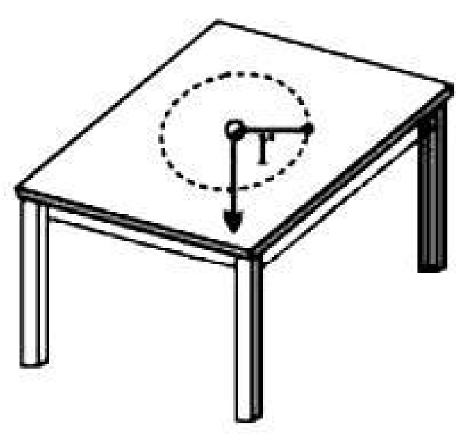
[MATRIX TYPE]

Q.21 If a bicycle moves forward and assume that the rider is not braking and pedaling at the same time. Match the column regarding friction on the wheels of bicycle :

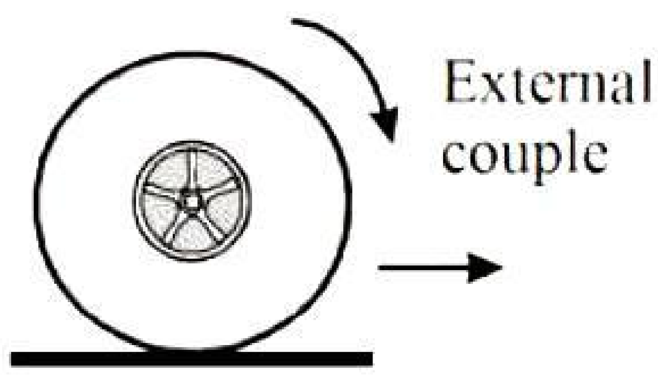
	Column-I		Column-II
(A)	When rear brakes are applied on a bicycle and it does not slide	(P)	Friction force will be forward on both wheels
(B)	When front brakes are applied on a bicycle and it does not slide.	(Q)	Friction force will be backwards on both wheels
(C)	When front and rear brakes are applied simultaneously so hard that both wheels stop rotating	(R)	Friction force will be forward on rear wheel and backward on front wheel
(D)	When force on pedals is applied to accelerate bicycle without sliding	(S)	Friction force will be backward on rear wheel and forward on front wheel

[SUBJECTIVE TYPE]

Q.22 A particle of mass m is attached to the end of a string and moves with speed v along a circle of radius r on a frictionless table. The string passes through a frictionless hole in the table. Find the work done by external agent if the string is slowly pulled so that the radius of circular orbit changes from r_0 to $r_0/2$.



Q.23 Consider a symmetric car wheel that is free to move across a horizontal surface. The wheel has a mass M = 10 kg, a radius R = 30 cm, and its moment of inertia around its axis is I = 0.45 kg·m^2. A clockwise external couple is applied around the axis through the center of mass of the wheel. The center of mass of the wheel is found to move forward with an acceleration a = 2 m/s^2. The coefficient of static friction is high enough to ensure that the wheel rolls without slipping. This is the process that makes a car accelerate. What is the couple (in N-m) applied externally?



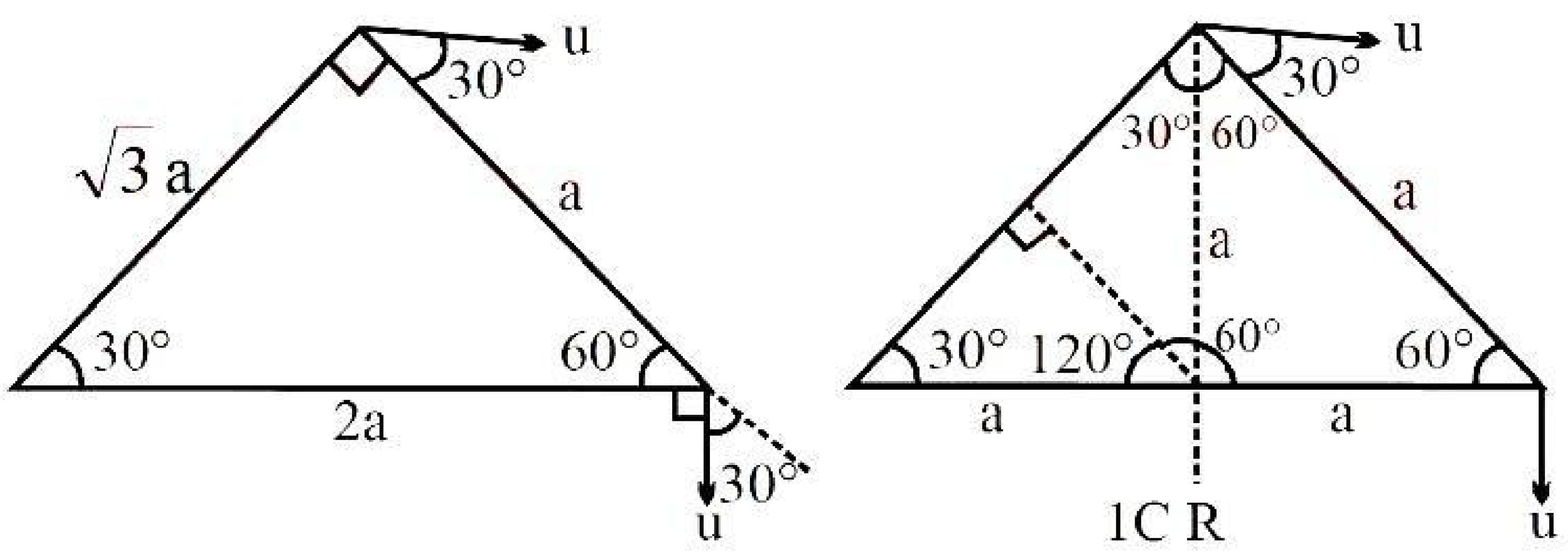
ANSWER KEY

Q.1	C	Q.2	C	Q.3	B	Q.4	C	Q.5	A	Q.6	B	Q.7	B
Q.8	C	Q.9	B	Q.10	B	Q.11	C	Q.12	C	Q.13	C	Q.14	A
Q.15	A	Q.16	B	Q.17	B,C,D	Q.18	A,B,C	Q.19	A,C,D	Q.20	A,C		
Q.21	(A)-S (B)-R (C)-Q (D)-R					Q.22	$(3/2)mv^2$			Q.23	0009		

HINTS AND SOLUTIONS

Q.1 C
Q.2 C
Q.3 B
Q.4 C
Q.5 A
Q.6 B
Q.7 B
Q.8 C
Q.9 B
Q.10 B
Q.11 C
Q.12 C
Q.13 C
Q.14 A
Q.15 A
Q.16 B
Q.17 BCD

Sol.



$V_c = w_a = V$

Q.18 ABC

Sol. C has max torque $\Rightarrow \omega_C$ max

B - energy dissipated

$$mg\sin\theta - \mu\, mg\cos\theta = ma_B \Rightarrow a_B > \frac{2}{3}\, g\sin\theta$$

$$a_C = \frac{g\sin\theta}{1+\frac{1}{2}} = \frac{2}{3}\, g\sin\theta$$

Q.19 ACD

Q.20 AC

Sol. $N_A + f_B = 2mg$

$N_B = f_A$

$mgR + -f_A R - f_B R = 0$

$mg = f_A + f_B$

Q.21 Ans. (A)-S (B)-R (C)-Q (D)-R

Sol.$_{SJ}$ In (A) we try to decrease ω of the rear wheel then friction will try to increase it. On front wheel at the point of contact with the ground $\omega \times r$ is greater than v as v decreases due to break. So that friction will act in forward direction on it.

In (B) we try to decrease ω of the front wheel friction will try to increase it.

In (C) sliding will start hence f_k will act.

In (D) we try to increase ω of rear wheel then friction will try to decrease it.

Q.22 Sol. Conserving angular momentum about hole

$mvr_0 = mv_1 r_0/2$

$v_1 = 2v$

Work done = $\Delta KE = (1/2)m[(2v)^2 - v^2] = (3/2)mv^2$

Q.23 Ans. 0009

Sol. $\tau - fR = 0.45\ \alpha$

$f = 10a = 10 \times 0.2 = 20N$

$$\tau - 20 \times 0.3 = 0.45 \times \frac{0.2}{0.3} = 3$$

$\tau = 9$ N-m