# Physicsaholics

**DPP – 6**

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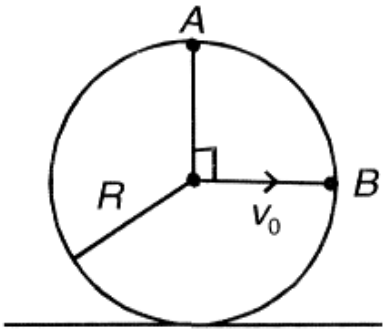
Video Solution on YouTube:- https://youtu.be/6dtpMz4DAd4

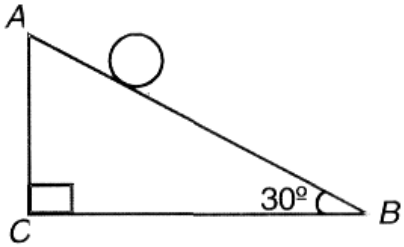
Written Solution on Website:- https://physicsaholics.com/note/notesDetalis/18

Q 1. A ring of radius R is rolling over rough horizontal surface with velocity $v_0$. Two points are located at A and B on rim of ring. Find angular velocity of A w.r.t. B



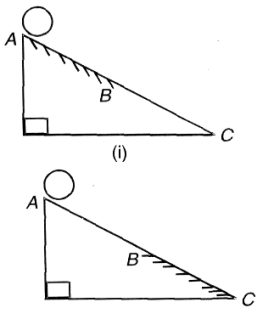

(a) his angular velocity increases
(b) his moment of inertia decreases
(c) He does positive work
(d) his kinetic energy increases

Q 2. Length AB in figure shown is 5 m. The body is released from A friction is sufficient for pure rolling to take place. The maximum time which anybody (which can roll) can take to reach bottom is



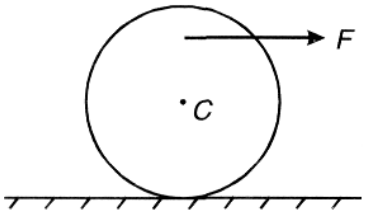

(a) 8 s
(b)2 s
(c) 6 s
(d)4 s

Q 3. In both figures all other factors are same except that in figure (i) AB is rough and BC is smooth while in figure (ii) AB is smooth and BC is rough. Kinetic energy of ball on reaching bottom




(a) is same in both the cases
(b) is greater in case (i)
(c) is greater is case (ii)
(d) information insufficient

Q 4. Direction of friction on ball if ball moves on rough surface



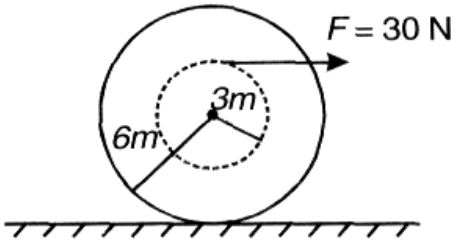

(a) Backwards (b) Forward
(c) Zero (d) Information insufficient

Q 5. Which of following statements are correct for rolling without slipping on rough horizontal ground?
(a)Acceleration of point in contact with ground is zero
(b)Speed of some points are zero
(c)Friction force may or may not be zero
(d)Work done by friction may or may not be zero

Q 6. Which of following statements are correct?
(a) If bicycle accelerates on road, friction on rear wheel is in forward direction
(b) If bicycle accelerates on road, friction on front wheel is in backward direction
(c) Friction on both wheels in forward direction
(d) Friction on both wheels in backward direction

**PASSAGE (Q.7 to Q.9)**

A homogenous cylinder has mass M= 10 kg & radius R = 6 m. It is accelerated by a force of 30 N as shown in figure. Coefficient of friction is sufficient for cylinder to roll without slipping.



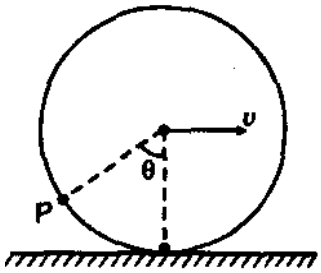

Q 7. Frictional force on the cylinder is

(a) 0N (b) 1 N (c) 2 N (d) 3 N

Q 8. Acceleration of the cylinder is
(a) 0 m/s$^2$ (b) 1 m/s$^2$
(c) 2 m/s$^2$ (d) 3 m/s$^2$

Q 9. Angular acceleration of the cylinder is
(a) 1 rad/s$^2$ (b) .5 rad/s$^2$
(c) .75 rad/s$^2$ (d) zero

Q 10. A hoop rolls on a horizontal ground without slipping with linear speed. Speed of a particle P on the circumference of the hoop at angle θ is :

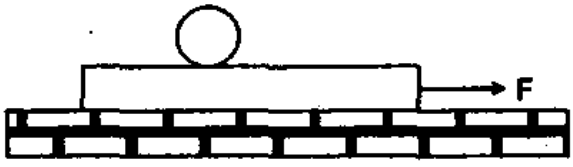



(a) $2v\,sin\left(\frac{\theta}{2}\right)$ (b) v sin θ
(c) $2v\,cos\left(\frac{\theta}{2}\right)$ (d) v cos θ

Q 11. A homogeneous cylinder of mass M and radius R is pulled on a horizontal plane by a horizontal force F acting through its mass centre. Assuming rolling without slipping the angular acceleration of the cylinder is:
(a) $\frac{3F}{2MR}$ (b) $\frac{2F}{3MR}$ (c) $\frac{F}{2MR}$ (d) $\frac{3F}{4MR}$

Q 12. A wheel of radius R rolls on the ground with a uniform velocity v. The relative acceleration of topmost point of the wheel with respect to the bottommost point is:
(a) $\frac{v^2}{R}$ (b) $\frac{2v^2}{R}$ (c) $\frac{v^2}{2R}$ (d) $\frac{4v^2}{R}$

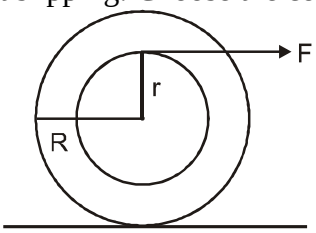
Q 13. A plank with a uniform sphere placed on it , is resting on a smooth horizontal plane. Plank is pulled to right by a constant force F. If sphere does not slip over the plank. Which of the following is incorrect?




(a) Acceleration of the centre of sphere is less than that of the plank
(b) Work done by friction acting on the sphere is equal to its total kinetic energy
(c) Total kinetic energy of the system is equal to work done by the force F
(d) None of the above

Q 14. A heavy homogeneous cylinder has a mass m and radius R. It is accelerated by a horizontal force F, which is applied through a rope wound around a light drum of

radius r attached to the cylinder. The coefficient of static friction is sufficient for the cylinder to roll without slipping. Choose the correct options :



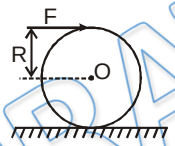
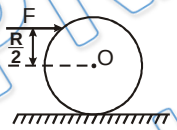
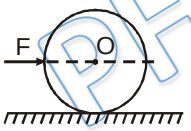
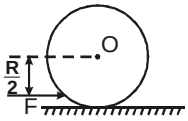

(a) acceleration of centre of cylinder is a = $\frac{2F}{3mR}$ (R + r)

(b) friction assumed to be in the opposite direction of F is f = $\frac{2}{3}\left(\frac{1}{2}-\frac{r}{R}\right)$ F

(c) If $\left(\frac{r}{R}\right) < \frac{1}{2}$ a will be greater than $\frac{F}{m}$

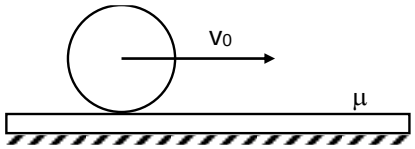
(d) Friction assumed to be in the direction of F is f = $\frac{2}{3}\left(\frac{1}{2}-\frac{r}{R}\right)$ F

Q 15. A uniform solid cylinder of mass m and radius R is placed on a rough horizontal surface where friction is sufficient to provide pure rolling. A horizontal force of magnitude F is applied on cylinder at different positions with respect to its centre O in each of four situations of column-I, due to which magnitude of acceleration of centre of mass of cylinder is a. Match the appropriate results in column-II for conditions of column-I.

| Column-I | Column-II |
|---|---|
| (A)  | (p) Friction force on cylinder will not be zero |
| (B)  | (q) a =F/m |
| (C)  | (r) a ≠F/m |
| (D)  | (s) the direction of friction force acting on cylinder is towards left |

Q 16. A solid sphere of mass m and radius R is placed on a plank of equal mass, which lies on a smooth horizontal surface. The sphere is given a sharp impulse in the horizontal direction so that it starts sliding with a speed of $v_0$. Find the time taken by the sphere

to start pure rolling on the plank. The coefficient of friction between plank and sphere is μ.



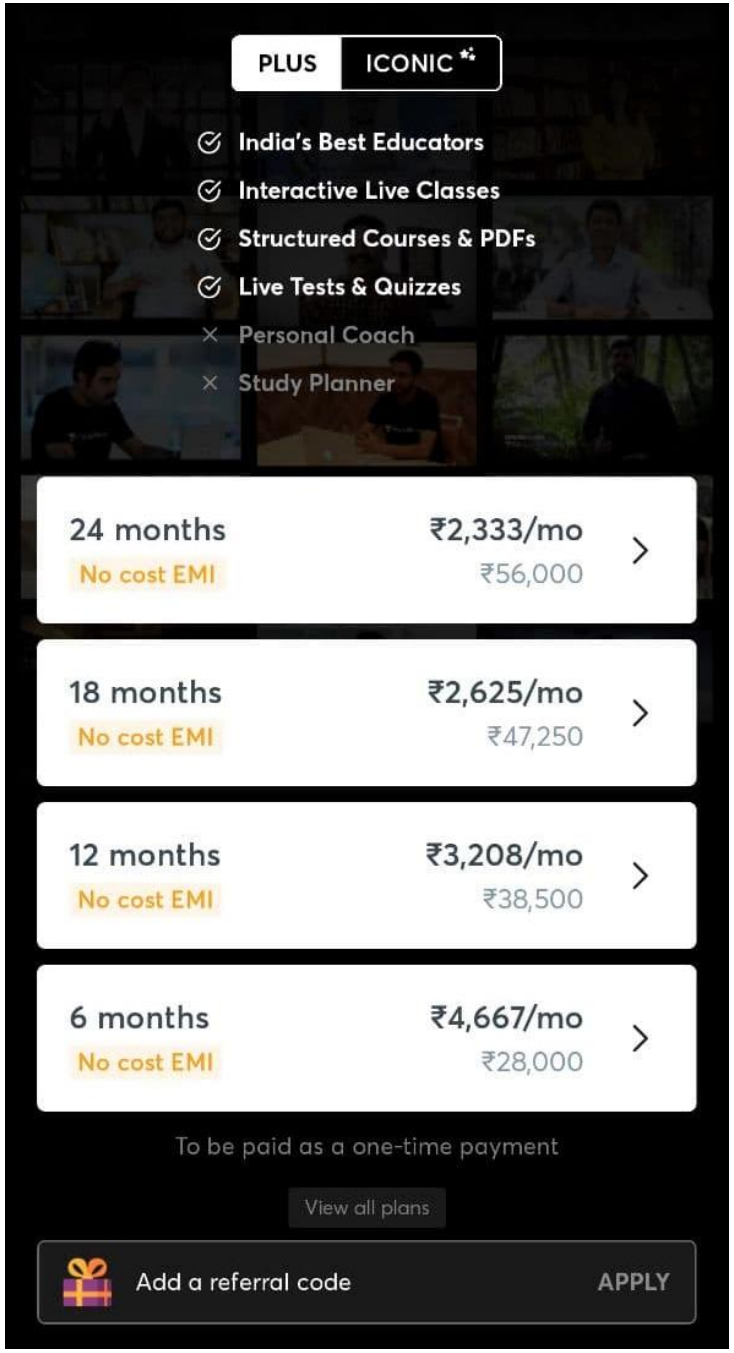

(a) $2v_o/9\mu g$ (b) $4v_o/9\mu g$
(c) $2v_o/3\mu g$ (d) $5v_o/9\mu g$



# Answer Key

| | | | | |
|---|---|---|---|---|
| **Q.1 a** | **Q.2 b** | **Q.3 b** | **Q.4 d** | **Q.5 b, c** |
| **Q.6 a, b** | **Q.7 a** | **Q.8 d** | **Q.9 b** | **Q.10 a** |
| **Q.11 b** | **Q.12 b** | **Q.13 a, b, c** | **Q.14 a, b** | **Q.16 a** |

**Ans.15** (A) p,r (B) q (C) p,r,s (D) p,r,s

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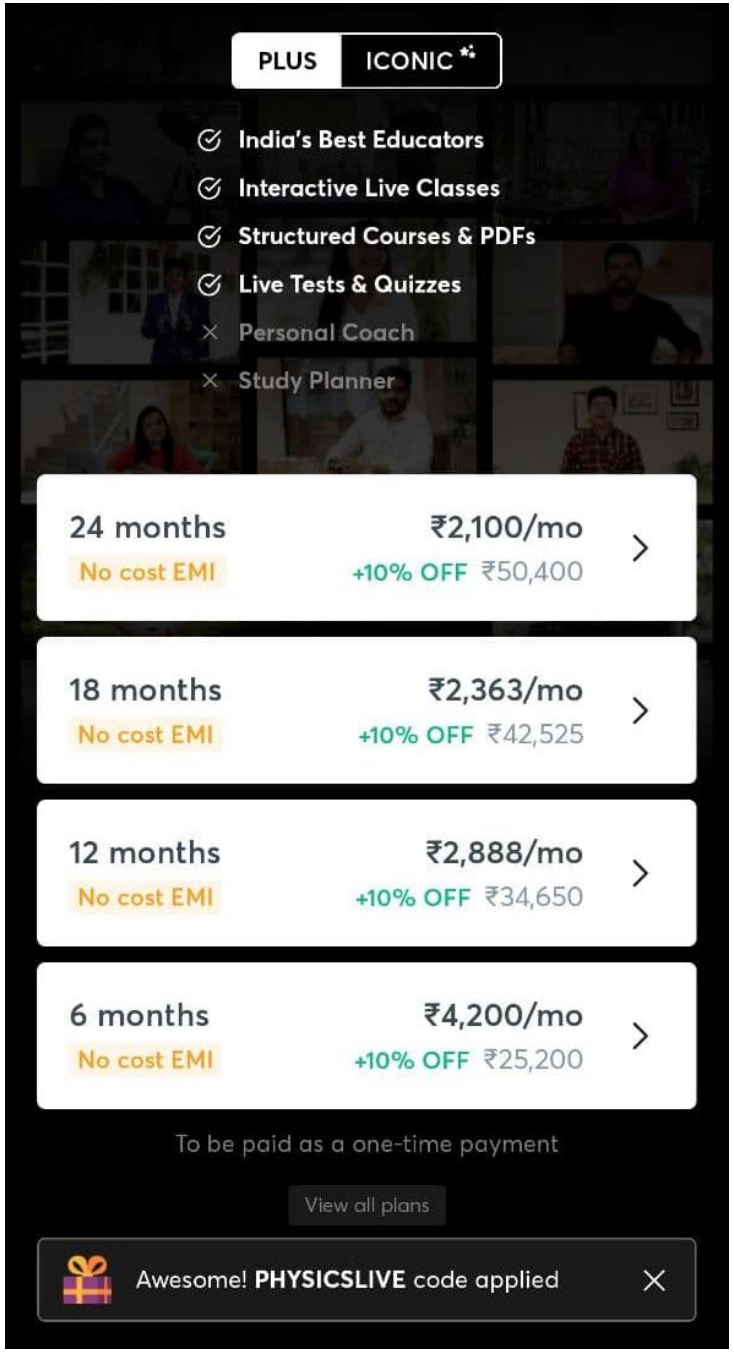


# Written Solution

**JEE Main & Advanced, NSEP, INPhO, IPhO**

**Physics DPP**

## DPP-6 Rotation: Rolling Motion

**By Physicsaholics Team**

Q1) A ring of radius R is rolling over rough horizontal surface with velocity $v_0$. Two points are located at A and B on rim of ring. Find angular velocity of A w.r.t. B

(a) ~~$\frac{v_0}{R}$~~

(b) $\frac{v_0}{R}\sqrt{2}$

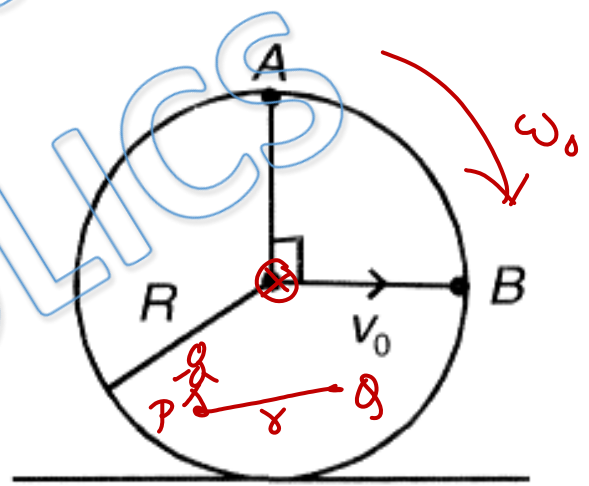
(c) $\frac{2v_0}{R}$

(d) $\frac{v_0}{R\sqrt{2}}$

$\omega_0 = \frac{v_0}{R}$

$\omega_{B,A} = \omega_0 = \frac{v_0}{R}$

$\omega_{Q,P} = \omega_0 = \frac{v_0}{R}$.



Q2) Length AB in figure shown is 5 m. The body is released from A friction is sufficient for pure rolling to take place. The maximum time which anybody (which can roll) can take to reach bottom is

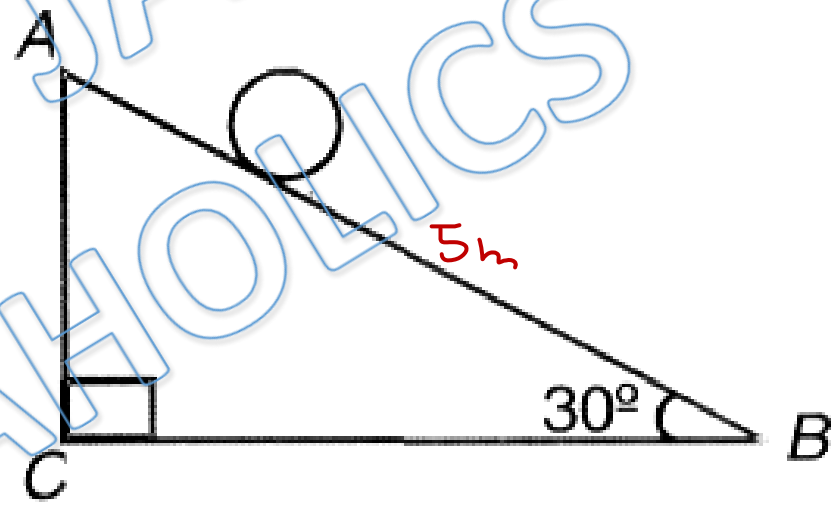
$$a_{min} = \frac{g\sin\theta}{1+\left(\frac{I}{mR^2}\right)_{max}} = \frac{10\times 1/2}{1+1}$$

$$a_{min} = \frac{5}{2}\ m/sec^2$$

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

$$5 = 0 + \frac{1}{2}\times\frac{5}{2}t^2$$

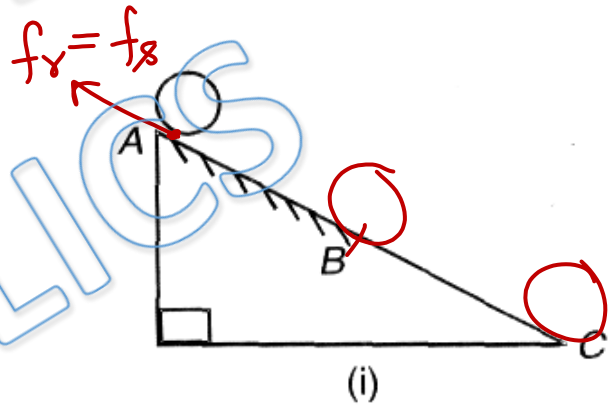
$$t = 2sec$$



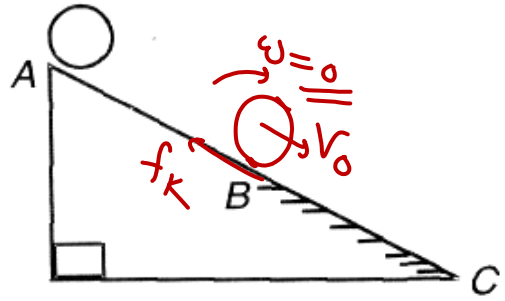

(a) 8 s (b) 2 s

(c) 6 s (d) 4 s

Q3) In both figures all other factors are same except that in figure (i) AB is rough and BC is smooth while in figure (ii) AB is smooth and BC is rough. Kinetic energy of ball on reaching bottom



(i)




(a) is same in both the cases

(b) ~~is~~ greater in case (i)

(c) is greater is case (ii)

(d) information insufficient

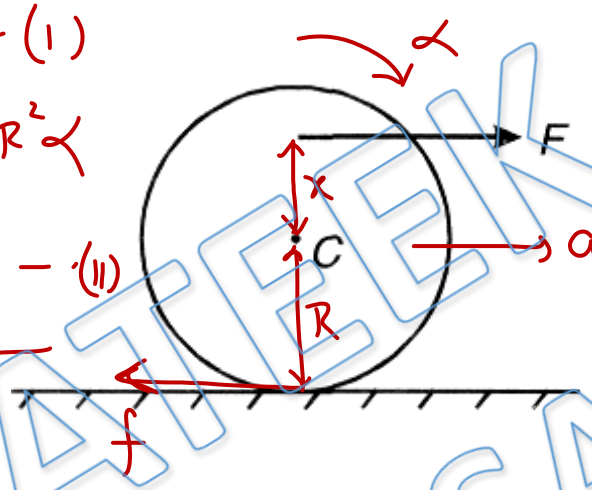
Q4) Direction of friction on ball if ball moves on rough surface

$F - f = ma$ — (I)

$Fx + fR = \frac{2}{5}mR^2\alpha$

$\frac{Fx}{R} + f = \frac{2}{5}ma$ — (II)

$F\left(1+\frac{x}{R}\right) = \frac{7}{5}ma$




$F - f = \frac{5}{7}F\left(1+\frac{x}{R}\right)$

$f = F\left[1 - \frac{5}{7}\left(1+\frac{x}{R}\right)\right]$

$= F\left[\frac{7 - 5(1+x/R)}{7}\right]$

$= F\left[\frac{2 - 5x/R}{7}\right]$

$= 5F\left[\frac{2R/5 - x}{7R}\right]$

(a) Backwards (b) Forward

(c) Zero (d) Information insufficient

Q5) Which of following statements are correct for rolling without slipping on rough horizontal ground?


(a) Acceleration of point in contact with ground is zero

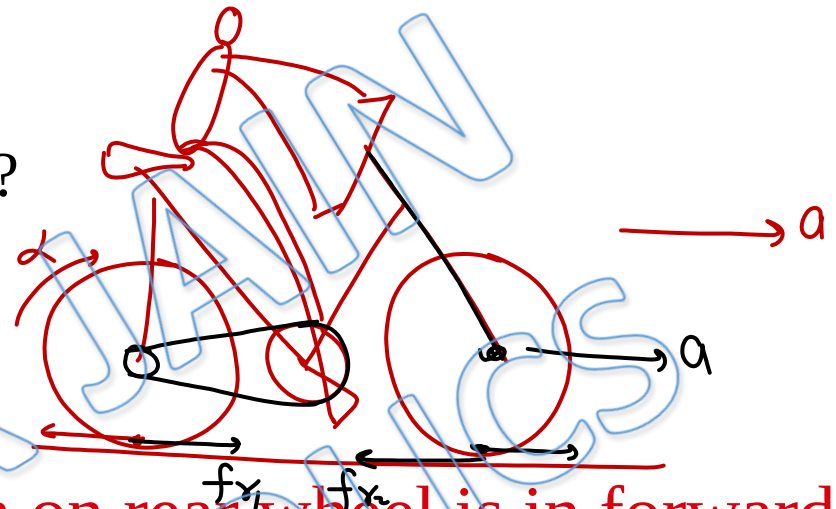
(b) Speed of some points are zero

(c) Friction force may or may not be zero

(d) Work done by friction may or may not be zero

$$W_{\text{of } f} = \int P\,dt = \int \vec{F}\cdot\vec{v}\,dt = 0$$

Q6) Which of following statements are correct?




(a)If bicycle accelerates on road, friction on rear wheel is in forward direction

(b)If bicycle accelerates on road, friction on front wheel is in backward direction

(c)Friction on both wheels in forward direction

(d)Friction on both wheels in backward direction

**PASSAGE**

A homogenous cylinder has mass M= 10 kg & radius R = 6 m. It is accelerated by a force of 30 N as shown in figure. Coefficient of friction is sufficient for cylinder to roll without slipping.

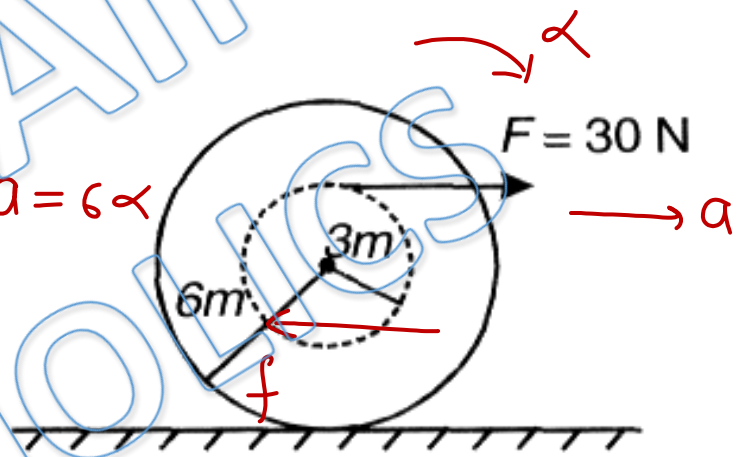
$30 - f = 10a$

$f \times 6 + 30 \times 3 = \frac{10 \times 36}{2}\alpha$

$f + 15 = 5a$

$30 - f = 10a$

$a = 6\alpha$




(Q7) Frictional force on the cylinder is

(a) 0N (b) 1 N (c) 2 N (d) 3 N

$45 = 15a$

$a = 3 m/sec^2$

$f + 15 = 15$

$f = 0$

Q8) Acceleration of the cylinder is

(a) 0 $m/s^2$

(b) 1 $m/s^2$

(c) 2 $m/s^2$

(d) 3 $m/s^2$

Q9) Angular acceleration of the cylinder is

$\alpha = \frac{a}{R}$

$= \frac{3}{6}$

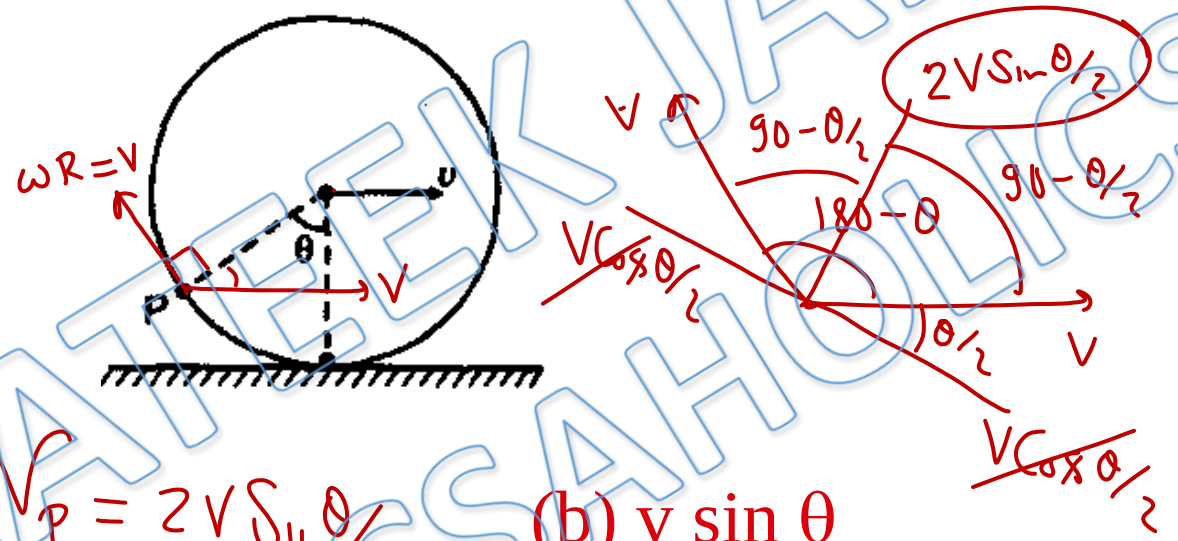
(a) 1 rad/s$^2$

(b) .5 rad/s$^2$

(c) .75 rad/s$^2$

(d) zero

Q10) A hoop rolls on a horizontal ground without slipping with linear speed. Speed of a particle P on the circumference of the hoop at angle θ is :



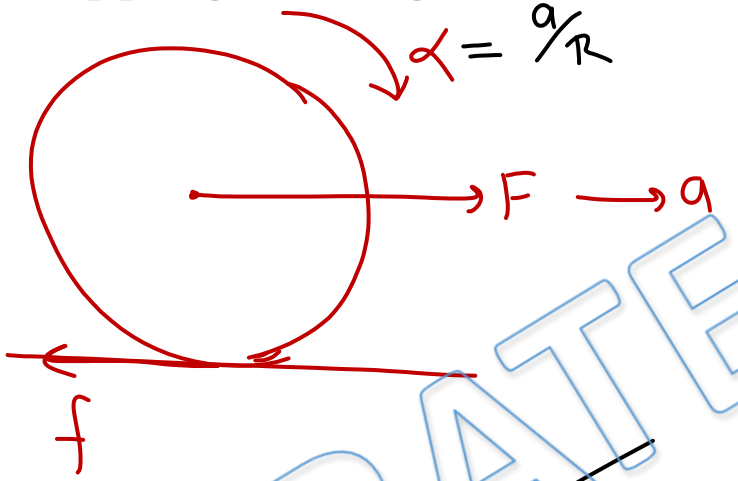

(a) $2v\ sin\left(\frac{\theta}{2}\right)$ $V_P = 2V\sin\theta/2$

(b) v sin θ

(c) $2v\ cos\left(\frac{\theta}{2}\right)$

(d) v cos θ

Q11) A homogeneous cylinder of mass M and radius R is pulled on a horizontal plane by a horizontal force F acting through its mass centre. Assuming rolling without slipping the angular acceleration of the cylinder is:




$F - f = Ma$

$F - \frac{Ma}{2} = Ma$

$F = \frac{3Ma}{2}$

$fR = \frac{MR^2}{2}\alpha$

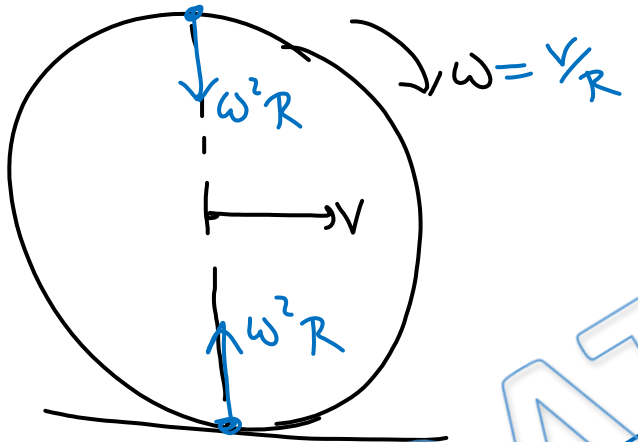
$f = \frac{Ma}{2}$

(a) $\frac{3F}{2MR}$ (b) $\frac{2F}{3MR}$ (c) $\frac{F}{2MR}$ (d) $\frac{3F}{4MR}$

$a = 2F/3M$

$\alpha = 2F/3MR$

Q12) A wheel of radius R rolls on the ground with a uniform velocity v. The relative acceleration of topmost point of the wheel with respect to the bottommost point is:




$a_{rel} = 2\omega^2 R$

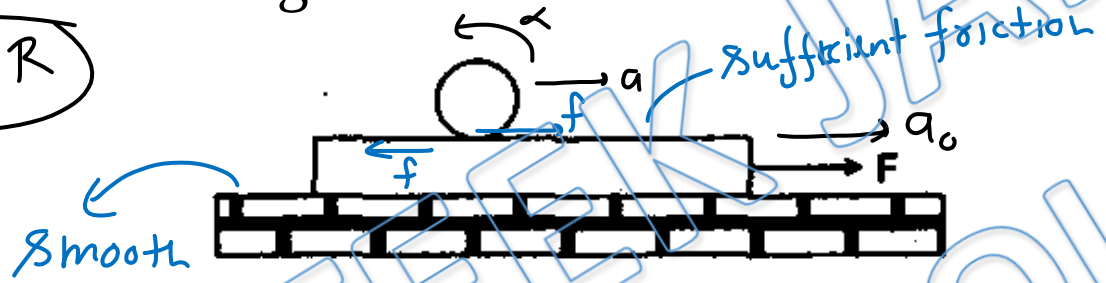
$= 2\frac{v^2}{R^2}R$

$= \frac{2v^2}{R}$

(a) $\frac{v^2}{R}$ (b) $\frac{2v^2}{R}$ (c) $\frac{v^2}{2R}$ (d) $\frac{4v^2}{R}$

Q13) A plank with a uniform sphere placed on it , is resting on a smooth horizontal plane. Plank is pulled to right by a constant force F. If sphere does not slip over the plank. Which of the following is incorrect?

$a_0 = a + \alpha R$



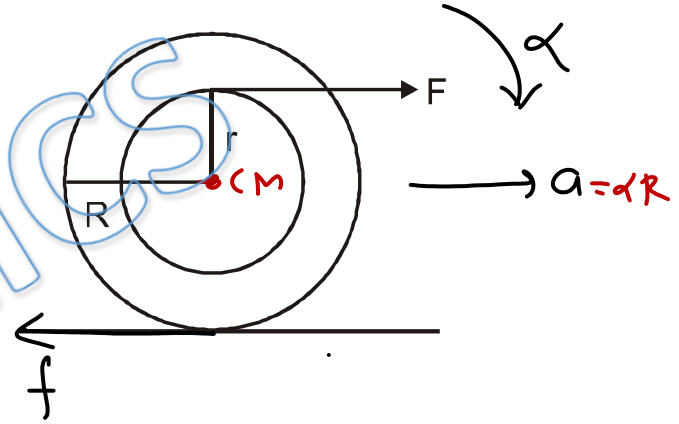

(a) Acceleration of the centre of sphere is less than that of the plank

(b) Work done by friction acting on the sphere is equal to its total kinetic energy

(c) Total kinetic energy of the system is equal to work done by the force F

(d) None of the above

Q14) A heavy homogeneous cylinder has a mass m and radius R. It is accelerated by a horizontal force F, which is applied through a rope wound around a light drum of radius r attached to the cylinder. The coefficient of static friction is sufficient for the cylinder to roll without slipping .Choose the correct options :




$F - f = ma$ --(I)

$F\gamma + fR = \frac{mR^2}{2}\alpha$

$F\frac{\gamma}{R} + f = \frac{ma}{2}$ --(II)

$F\left(1+\frac{\gamma}{R}\right) = \frac{3ma}{2}$

$a = \frac{2F(R+\gamma)}{3mR}$

(a) acceleration of centre of cylinder is $a = \frac{2F}{3mR}(R + r)$

(b) friction assumed to be in the opposite direction of F is

$f = \frac{2}{3}\left(\frac{1}{2} - \frac{r}{R}\right) F$

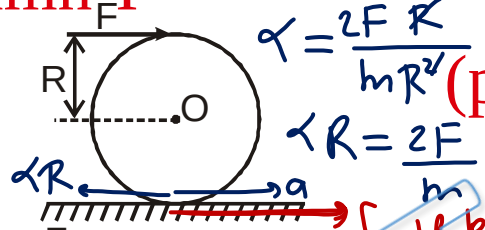
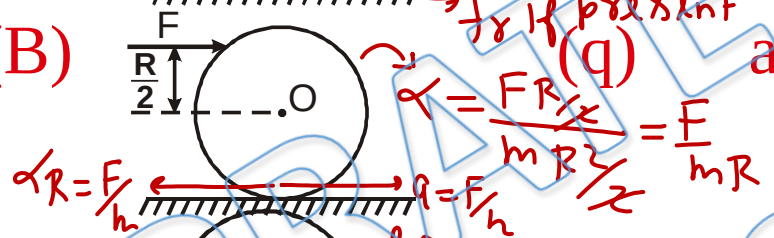
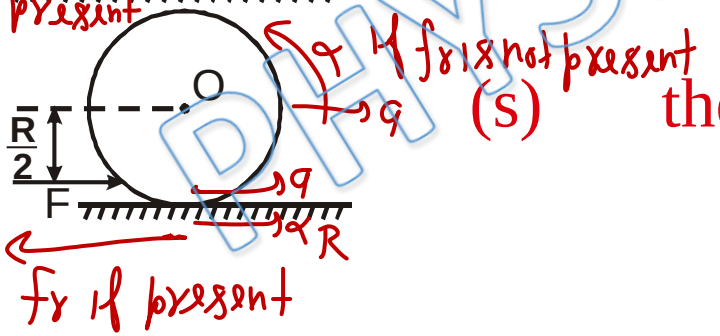
$f = F - \frac{2F(R+\gamma)}{3R} = F\left[\frac{3R - 2R - 2\gamma}{3R}\right]$

$= F\left[\frac{1}{3} - \frac{2\gamma}{3R}\right] = \frac{2F}{3}\left[\frac{1}{2} - \frac{\gamma}{R}\right]$

(c) If $\left(\frac{r}{R}\right) < \frac{1}{2}$ a will be greater than $\frac{F}{m}$

(d) Friction assumed to be in the direction of F is $f = \frac{2}{3}\left(\frac{1}{2} - \frac{r}{R}\right) F$

Q15) A uniform solid cylinder of mass m and radius R is placed on a rough horizontal surface where friction is sufficient to provide pure rolling. A horizontal force of magnitude F is applied on cylinder at different positions with respect to its centre O in each of four situations of column-I, due to which magnitude of acceleration of centre of mass of cylinder is a. Match the appropriate results in column-II for conditions of column-I.

| Column-I | | Column-II | |
|---|---|---|---|
| (P, γ) | (A)  | (p) | Friction force on cylinder will not be zero |
| ✓ | (B)  | (q) | a = F/m |
| P, γ, S | (C)  | (r) | a ≠ F/m |
| P, γ, S | (D)  | (s) | the direction of friction force acting on cylinder is towards left |

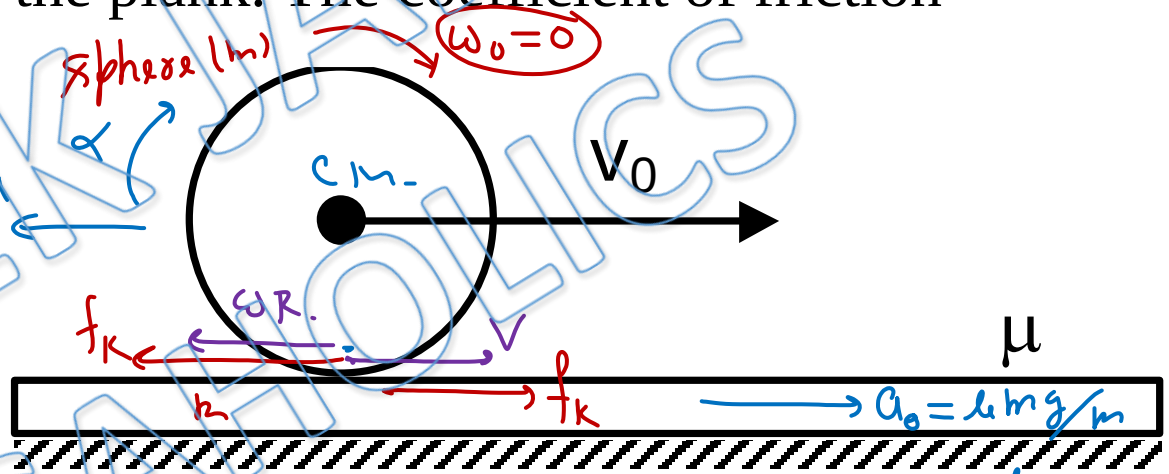
Q16) A solid sphere of mass m and radius R is placed on a plank of equal mass, which lies on a smooth horizontal surface. The sphere is given a sharp impulse in the horizontal direction so that it starts sliding with a speed of $v_0$. Find the time taken by the sphere to start pure rolling on the plank. The coefficient of friction between plank and sphere is μ.

(a) $2v_o/9\mu g$

(b) $4v_o/9\mu g$

(c) $2v_o/3\mu g$

(d) $5v_o/9\mu g$




$f_K = \mu mg$

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

$2 + \frac{5}{2}$

$= 9/2$

$\tau_{CM} = I_{CM}\alpha$

$\Rightarrow \mu mgR = \frac{2}{5}mR^2\alpha \Rightarrow \alpha = \frac{5\mu g}{2R}$

velocity of plank $= \mu gt$

velocity of bottom point of sphere at $t = t$

$= (V_0 - \mu gt) - \left(\frac{5\mu gt}{2R}\right)R$

$V_0 = \frac{9}{2}\mu gt \Rightarrow t = \frac{2V_0}{9\mu g}$

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