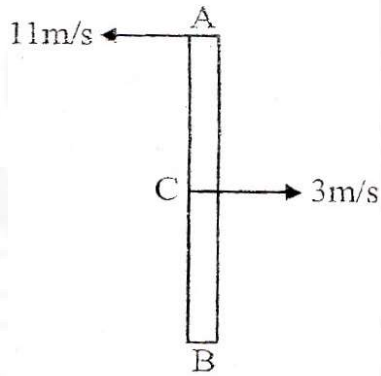
PHYSICS: **Max. Marks : 60**

SECTION – I

(MULTIPLE CORRECT CHOICE TYPE)

This section contains **8 multiple choice questions.** Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which **ONE OR MORE is/ are correct**

1. A uniform rod AB of length 7 m is undergoing combined rotational and translational motion such that, at some instant of time, velocities of end point A and centre C are both perpendicular to the rod and opposite in direction, having magnitude 11 m/s and 3 m/s respectively as shown in the figure. Velocity of centre C and angular velocity of the rod remains constant



A) Acceleration of point A is $56\,m/s^2$

B) Acceleration of point B is $56\,m/s^2$

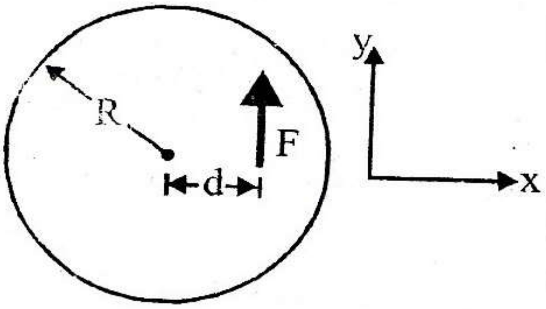
C) At the instant shown in the figure acceleration of point B is more than that of point A. (in magnitude)

D) Angular velocity of the rod is 4 rad/sec

2. A uniform thin flat isolated disc is floating in space. It has radius R and mass m.

A force F is applied to it a distanced $d = \frac{R}{2}$ from the center in the y-direction.

Treat this problem as two dimensional. At the instant t = 0 the



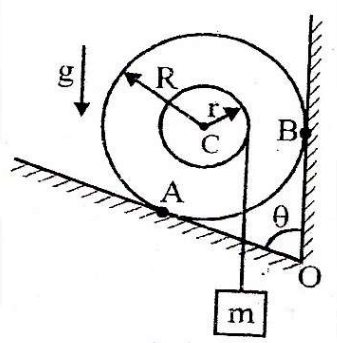
A) Acceleration of the center of the disc is F/m.

B) Angular acceleration of the disk is F/mR.

C) Acceleration of leftmost point on the disc is zero

D) Point which is instantaneously unaccelerated is the rightmost point.

3. A massless spool of inner radius r, outer R is placed against vertical wall and tilted split floor as shown. A light inextensible thread is tightly wound around the spool through which a mass m is hanging. There exists no friction at point A, while the coefficient of friction between spool and point B is μ. The angle between two surfaces is θ.



A) The magnitude of force on the spool at B in order to maintain equilibrium is $mg\sqrt{\left(\frac{r}{R}\right)^2+\left(1-\frac{r}{R}\right)^2\frac{1}{tan^2\theta}}$

B) The magnitude of force on the spool at B in order to maintain equilibrium is $mg\left(1-\frac{r}{R}\right)\frac{1}{tan\theta}$

C) The minimum value of μ for the system to remain in equilibrium is $\frac{cot\theta}{(R/r)-1}$

D) The minimum value of μ for the system to remain equilibrium is $\frac{tan\theta}{(R/r)-1}$

4. Which of the following statements is/are true

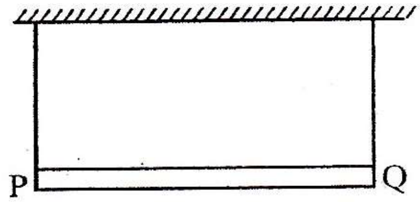
A) Work done by kinetic friction on a rigid body may be positive

B) A uniform sphere rolls up an inclined plane without sliding. The friction force on it will be up the incline. (Only contact force and gravitational force is acting)

C) A uniform sphere rolls down an inclined plane without sliding. The friction on it will be up the incline. (Only contact force and gravitational force is acting)

D) A uniform sphere is left from rest from the top of a rough inclined plane. It moves down the plane with slipping. The friction force on it will be up the incline.

5. A horizontal rod of mass 'M' and length 'L' is tied to two vertical string symmetrically as shown in the figure. One of the strings at end Q is cut at t = 0 and the rod starts rotating about the other end P. Then



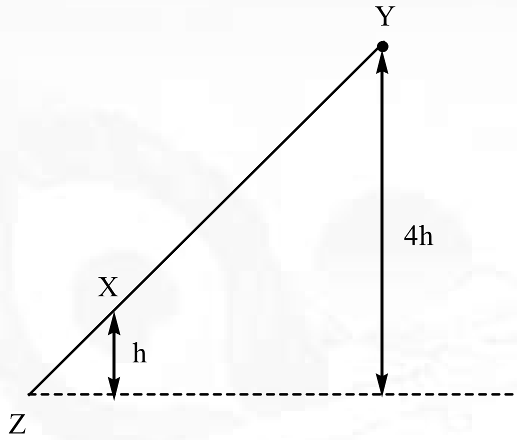
A) At t =0, angular acceleration of rod about P is 3g/2L.

B) At t = 0, angular acceleration of rod about C.M. of rod is 3g/2L.

C) At t = 0, acceleration of C.M. of rod is 3g/4 in downward direction.

D) At t = 0, tension in the string at P is Mg/4.

6. Two identical wheels A and B are released from rest from points X and Y respectively on an inclined plane as shown in the figure. Which of the following statement(s) is/are incorrect?



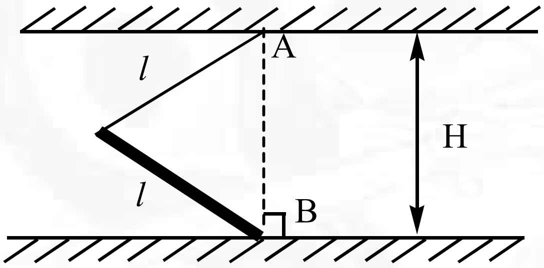
A) Wheel B takes twice as much time to roll from Y to Z than that of wheel A from X to Z

B) At point Z center of mass velocity of wheel A is four times that of wheel B

C) Center of acceleration of the wheel A is twice that of the wheel B

D) Both wheels take same time to arrive at point Z.

7. A uniform rod with length l is attached with a weightless thread(whose length is also l) to the ceiling at point A. The bottom end of the rod rests on a frictionless horizontal floor at point B, which is exactly below point A. The length of AB is H, $l < H < 2l$. The rod begins to slide from rest. The maximum velocity of the centre of rod during subsequent motion



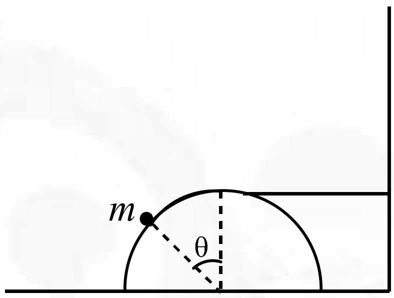
A) $\sqrt{g(H-l)}$

B) $\sqrt{g\left(l-\frac{H}{2}\right)}$

C) $\sqrt{g\left(\frac{H}{2}\right)}$

D) Cannot be determined

8. A point object of mass m is slipping down on a smooth hemi-spherical body of mass M and radius R as shown in figure. The point object is tied to a wall with the help of a light string. At $\theta = 60^o$, the speed of the hemisphere is v towards the wall and its acceleration is a. Mark the correct statements



A) The velocity of the particle at $\theta = 60^o$ is v with respect to ground

B) The acceleration of the particle at $\theta = 60^o$ is $\frac{v^2}{R}$ with respect to hemisphere

C) The acceleration of the particle at $\theta = 60^o$ with respect to ground is

$$\sqrt{\left(\frac{v^2}{R}+\frac{(\sqrt{3})(a)}{2}\right)^2+\left(\frac{a}{2}\right)^2}$$

D) The velocity the particle at $\theta = 60^o$ is $\frac{v}{2}$ with respect to ground

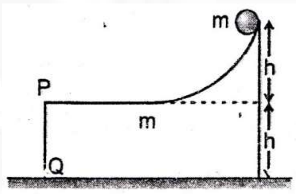
SECTION - II
(COMPREHENSION TYPE)

This section contains **4 groups of questions**. Each group has 2 multiple choice questions based on a paragraph. Each question has 4 choices A), B), C) and D) for its answer, out of which **ONLY ONE** is **correct**.

Paragraph for Questions 9 and 10

A small ball (uniform solid sphere) of mass m is released from the top of a wedge of the same mass m. The wedge is free to move on a smooth horizontal surface. The ball rolls without sliding on the wedge. The required height of the wedge are as mentioned in the figure.

9. The total kinetic energy of the ball just before it falls on the ground



A) 2 mgh B) mgh C) $\frac{31}{18}mgh$ D) $\frac{mgh}{2}$

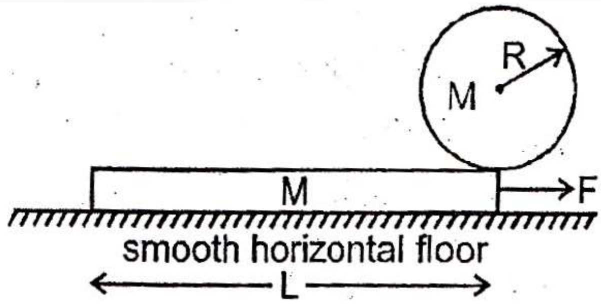
10. The horizontal separation between the ball and the edge 'PQ' of wedge just before the ball falls on the ground is

A) $\frac{3\sqrt{10}}{2}h$ B) $\frac{2\sqrt{10}}{3}h$ C) 2h D) $\frac{\sqrt{10}}{3}h$

Paragraph for Questions 11 and 12

A uniform disc of mass M and radius R initially stands vertically on the right end of a horizontal plank of mass M and length L, as shown in the figure

The plank rests on smooth horizontal floor and friction between disc and plank is sufficient high such that disc rolls on plank without slipping. The plank is pulled to right with a constant horizontal force of magnitude F.



11. The magnitude of acceleration of plank is

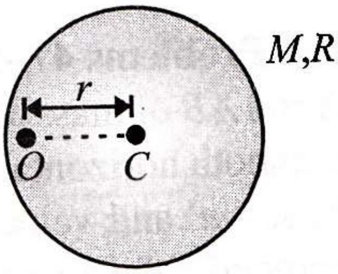
A) $\frac{F}{8M}$ B) $\frac{F}{4M}$ C) $\frac{3F}{2M}$ D) $\frac{3F}{4M}$

12. The magnitude of angular acceleration of the disc is

A) $\frac{F}{4mR}$ B) $\frac{F}{8mR}$ C) $\frac{F}{2mR}$ D) $\frac{3F}{2mR}$

Paragraph for Questions 13 and 14

A disc of mass M and radius R can rotate freely in a vertical plane about a horizontal axis at O distance r from the centre of the disc as shown in Fig. The disc is released from rest in the shown position. Answer the following questions based on the above information.



13. The angular acceleration of the disc when OC rotates by an angles of 37^o is

A) $\frac{8rg}{5\left[R^2+2r^2\right]}$ B) $\frac{5rg}{4\left[R^2+2r^2\right]}$ C) $\frac{10rg}{3\left[R^2+2r^2\right]}$ D) $\frac{8rg}{5R^2}$

14. The angular velocity of the disc in the above described case is

A) $\sqrt{\frac{8gr}{5\left[R^2+2r^2\right]}}$

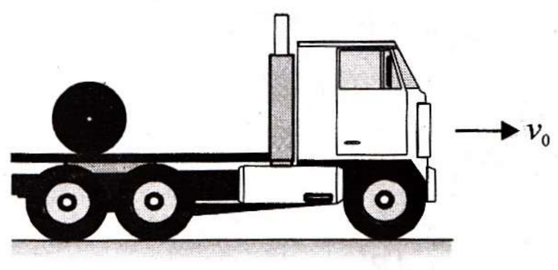
B) $I_z = I_x + I_y / 2, \frac{15}{32}MR^2$

C) $\sqrt{\frac{12gr}{5\left[R^2+2r^2\right]}}$

D) $\sqrt{\frac{12gr}{5R^2}}$

Paragraph for Questions 15 and 16

A sold sphere of mass M and radius R is initially at rest. Solid sphere is gradually lowered onto a truck moving with constant velocity v_0



15. What is the final speed of the sphere's centre of mass in ground frame when eventually pure rolling sets in

A) $\frac{5}{7}v_0$ B) $\frac{2}{7}v_0$ C) $\frac{7}{5}v_0$ D) $\frac{7}{2}v_0$

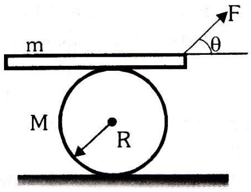
16. If a sphere with twice the radius and four times the mass had been used; what would have been its final speed of center of mass sphere with respect to ground?

A) $\frac{5}{7}v_0$ B) $\frac{2}{7}v_0$ C) $\frac{7}{5}v_0$ D) $\frac{7}{2}v_0$

SECTION – III
(MATRIX MATCH TYPE)

This section contains **4 multiple choice questions.** Each question has matching lists. The codes for the lists have choices (A), (B), (C), and (D) out of which **ONLY ONE** is correct.

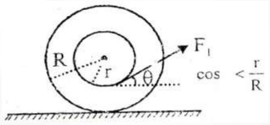
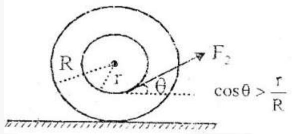
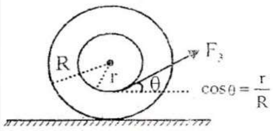
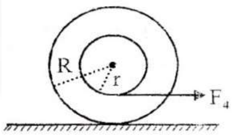
17. Consider a cylinder of mass M and radius R lying on a rough horizontal plane. It has a plank lying on its top as shown in figure. A force F is applied on the plank such that the plank moves and causes the cylinder to roll. The plank always remains horizontal. There is no slipping at any point of contact



Column-I		Column-II
A)	The magnitude of acceleration of the plank	p) $\frac{3MF\cos\theta}{[3M+8m]}$
B)	The magnitude of frictional force acting on the plank	q) $\frac{MF\cos\theta}{[3M+8m]}$
C)	Magnitude of acceleration of centre of mass of the cylinder	r) $\frac{8F\cos\theta}{3M+8m}$
D)	The frictional force on the cylinder at the point of contact with the horizontal plane	s) $\frac{4F\cos\theta}{3M+8m}$

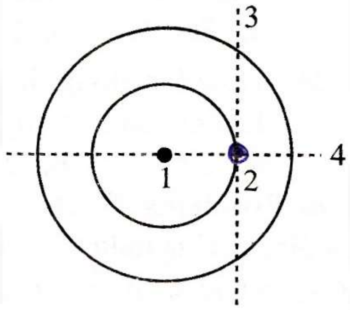
A) A – r; B – p; C – s; D – q
B) A – s; B – r; C – p; D – q
C) A – p; B – q; C – r; D – s
D) A – p; B – q; C – s; D – r

18. A spool is lying on a rough horizontal surface. In the following question, some situations are given in column I and some conclusions or relevant data in column-II. Match the column I with column II

Column-I	Column -II
A) 	p) a_{cm} is towards left
B) 	q) a_{cm} is towards right
C) 	r) friction acts towards left
D) 	s) friction acts towards right

A) A – pr; B – r; C – r; D – qr
B) A – pr; B – qr; C – r; D – qr
C) A – qr; B – pr; C – r; D – pr
D) A – qr; B – pr; C – r; D – qr

19. From a uniform disc of mass M and radius R, a concentric disc of radius R/2 is cut out. For the remaining annular disc: I_1 is the moment of inertia about axis '1', I_2 about '2', I_3 about '3' and I_4 about '4'. Axes '1' and '2' are perpendicular to the disc and '3' and '4' are in the plane of the disc. Axes '2', '3' and '4' intersect at a common point.

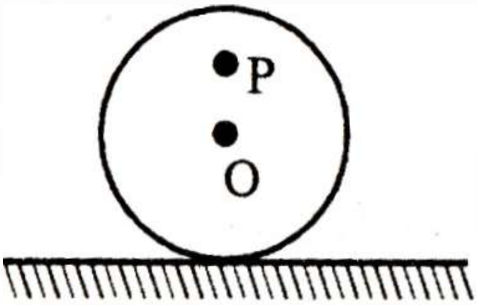


Match the following

COLUMN-I	COLUMN-II
A) I_1 is equal to	p) $\frac{21}{32}MR^2$
B) I_2 is equal to	q) $I_1/2$
C) I_3+I_4 is equal to	r) $\frac{15}{32}MR^2$
D) I_2-I_3 is equal to	s) $2I_1$

A) A – p; B – q; C – r; D – p
B) A – q; B – p; C – p; D – r
C) A – r; B – p; C – p; D – q
D) A – s; B – p; C – p; D – r

20. A uniform disc rolls without slipping on a rough horizontal surface with uniform angular velocity. Point O is the centre of disc and P is a point on disc as shown. In each situation of column I a statement is given and the corresponding results are given in column-II. Match the statement in column-I with the results in column-II



Column I	Column II
A) The velocity of point P marked on the disc	p) Change in magnitude with time
B) The acceleration of point P marked on the disc	q) Is always directed from the given point to centre of disc
C) The tangential acceleration of point P	r) Is always zero
D) The acceleration of point on disc which is in contact with rough horizontal surface	s) Is non-zero and remains constant in magnitude

A) A – s; B – q; C – p; D – s
B) A – p; B – qs; C – p; D – qs
C) A – p; B – qs; C – r; D – qs
D) A – r; B – s; C – p; D – q