TEST

# JEE Mains PYQs System of particles & rotational motion (Physics Master Academy)

## QUESTIONS

SECTIONS

1. Section A - 35 Questions

### Section 1 : Section A - 35 Questions

SECTION INSTRUCTIONS

This section contains 35 MCqs. +4 for every correct answer, -1 for every incorrct answer.

**1** The position of the centre of mass of a uniform semicircular wire of radius 'R' placed in x-y plane with its centre at the origin and the line joining its ends as x axis is given by $\left(0, \frac{xR}{\pi}\right)$. Then the value of |x| is ____

- 1
- 2
- 3
- 4

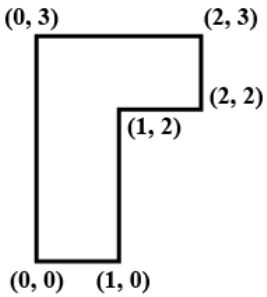
Correct: +4 · Incorrect: -1

**2** The centre of mass of a solid hemisphere of radius 8 cm is x cm from the centre of the flat surface. Then value of x is ____

- 1
- 2
- 3
- 4

Correct: +4 · Incorrect: -1

**3** The coordinates of centre of mass of a uniform flag shaped lamina (thin flat plate) of mass 4kg. (The coordinates of the same are shown in kgure) are:




- (1.25m, 1.50m)
- (0.75m, 1.75m)
- (0.75m, 0.75m)
- (1m, 1.75m)

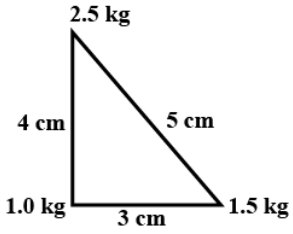
Correct: +4 · Incorrect: -1

**4** A shown in kgure when a spherical cavity (centred at O) of radius 1 is cut out of a uniform sphere of radius R (centred at C), the centre of mass of remaining (shaded) part of sphere is at G, i.e. on the surface of the cavity. R can be determined by the equation


- $(R^2 + R + 1)(2 - R) = 1$
- $(R^2 - R - 1)(2 - R) = 1$
- $(R^2 - R + 1)(2 - R) = 1$
- $(R^2 + R - 1)(2 - R) = 1$

Correct: +4 · Incorrect: -1

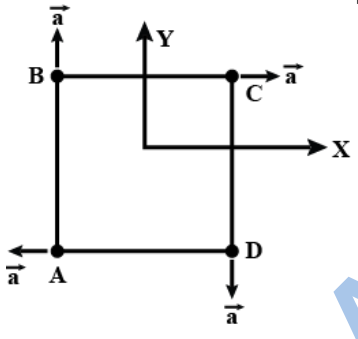
**5** Three points particles of masses 1.0kg, 1.5kg, and 2.5kg are placed at three corners of a right angle triangle of sides 4.0 cm and 3.0cm and 5.0 cm as shown in kgure. The centre of mass of the system is at a point



- 0.6cm right and 2.0cm above 1kg mass
- 1.5cm right and 1.2cm above 1kg mass
- 2.0cm right and 0.9cm above 1kg mass
- 0.9cm right and 2.0cm above 1kg mass

Correct: +4 · Incorrect: -1

**6** Four particles A, B, C and D with masses $m_A = m$, $M_B = 2m$, $m_C = 3m$, $m_D = 4m$ are at the corners of a square. They have accelerations of equal magnitude with directions as shown. The acceleration of the centre of mass of the particles is




- $\frac{a}{5}(\hat{i}-\hat{j})$
- a
- $\frac{a}{5}(\hat{i}+\hat{j})$
- zero

Correct: +4 · Incorrect: -1

**7** The angular speed of truck is increased from 900 rpm to 2460 rpm in 26 seconds. The number of evolutions by the truck engine during this time is____

- 722
- 725
- 728
- 730

Correct: +4 · Incorrect: -1

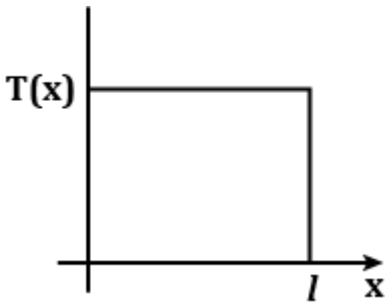
**8** A particle of mass m is kxed to one end of a light spring having force constant k and unstretched length l. The other end is kxed. The system is given an angular speed ω about the kxed end of the spring such that it rotates in a circle in gravity free space. Then the stretch in

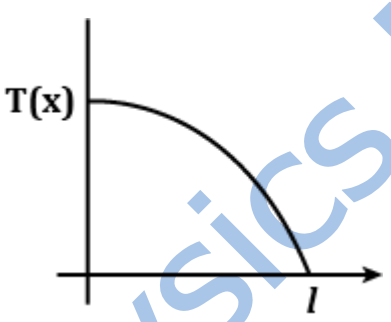
the spring is

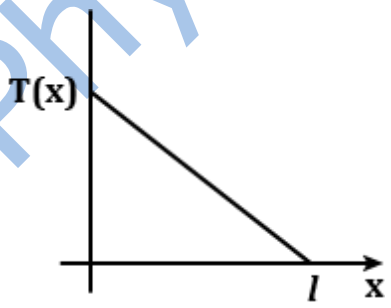
- $\frac{ml\omega^2}{k-\omega m}$
- $\frac{ml\omega^2}{k-m\omega^2}$
- $\frac{ml\omega^2}{k+m\omega^2}$
- $\frac{ml\omega^2}{k+m\omega}$

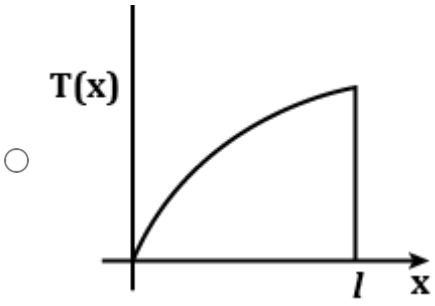
Correct: +4 · Incorrect: -1

**9** A uniform rod of length is being rotated in a horizontal plane with a constant angular speed about an axis passing through one of its ends. IF the tension generated in the rod due to rotation is T(x) at a distance x from the axis, then which of the following graphs depicts it most closely?






Correct: +4 · Incorrect: -1

**10** A long cylindrical vessel is half klled with a liquid. When the vessel is rotated about its own vertical axis, the liquid rises up near the wall. If the radius of vessel is 5cm and its rotational speed is 2 rotations per second, then the difference in the heights between the centre and the sides, in cm, will be

- 2.0
- 0.1
- 0.4
- 1.2

Correct: +4 · Incorrect: -1

**11** A particle is moving with a uniform speed in a circular orbit of radius R in a central force inversely proportional to the nth power of R. If the period of rotation of the particle is T, then:

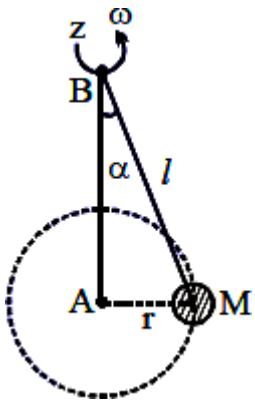
- $T \propto R^{3/2}$ for any n
- $T \propto R^{n/2+1}$
- $T \propto R^{(n+1)/2}$
- $T \propto R^{n/2}$

Correct: +4 · Incorrect: -1

**12** Angular momentum of a single particle moving with constant speed along circular path:

- changes in magnitude but remains same in the direction
- remains same in magnitude and direction
- remains same in magnitude but changes in the direction
- is zero

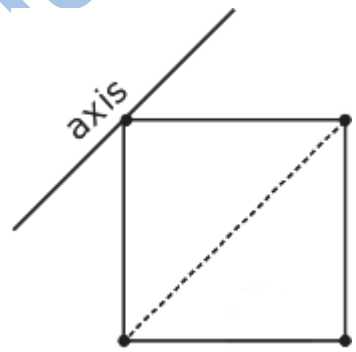
**13** A mass M hangs on a massless rod of length l which rotates at a constant angular frequency. The mass M moves with steady speed in a circular path of constant radius. Assume that the system is in steady circular motion with constant angular velocity $\omega$. The angular momentum of M about point A is $L_A$ which lies in the positive z direction and the angular momentum of M about point B is $L_B$. The correct statement for this system is




- ○ $L_A$ is constant both in magnitude and direction
- ○ $L_B$ is constant in direction with varying magnitude
- ○ $L_A$ and $L_B$ are both constant in magnitude and direction
- ○ $L_B$ is constant both in magnitude and direction

Correct: +4 · Incorrect: -1

**14** Four point masses each of mass m are kxed at the corners of a square of side l. The square is rotating with angular frequency w, about an axis passing through one of the corners of the square and parallel to its diagonal as shown in kgure. The angular momentum of the square about this axis is



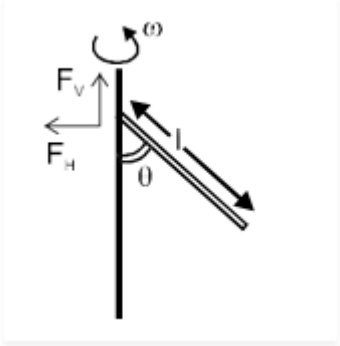

- ○ $ml^2\omega$
- ○ $4\ ml^2\omega$
- ○ $3\ ml^2\omega$
- ○ $2\ ml^2\omega$

Correct: +4 · Incorrect: -1

**15** A uniform rod of length 'l' is pivoted at one of its ends on a vertical shaft of the negligible radius. When the shaft rotates at angular speed $\omega$ the rod makes an angle $\theta$ with it (see kgure). To knd $\theta$ equate the rate of change of angular momentum (direction going into paper)

$\frac{ml^2}{12}\omega^2 sin\theta cos\theta$

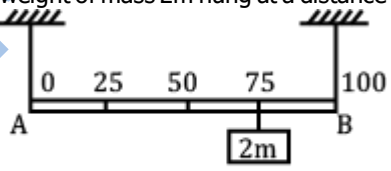
about the centre of mass (CM) to the torque provided by the horizontal and vertical forces $F_H$ and $F_V$ about the CM. The value of $\theta$ is




- $cos\theta = \frac{2g}{3l\omega^2}$
- $cos\theta = \frac{g}{2l\omega^2}$
- $cos\theta = \frac{g}{l\omega^2}$
- $cos\theta = \frac{3g}{2l\omega^2}$

Correct: +4 · Incorrect: -1

**16** Shown in the kgure is rigid and uniform one meter long rod AB held in horizontal position by two strings tied to its ends and attached to the ceiling. The rod is of mass m and has another weight of mass 2m hung at a distance of 75 cm from A. The tension in the string at A is




- 0.5 mg
- 2 mg
- 0.75 mg
- 1 mg

Correct: +4 · Incorrect: -1

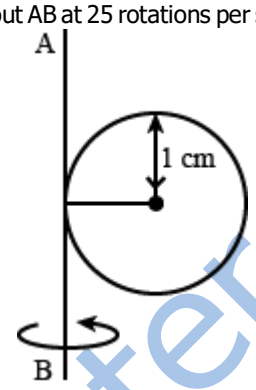
**17** The time dependence of the position of a particle of mass m = 2 is given by $\vec{r}(t) = 2t\hat{i}$

$-3t^2\hat{j}$. Its angular momentum, with respect to the origin at time t = 2 is

- $48(\hat{i}+\hat{j})$
- $36\hat{k}$
- $-34(\hat{k}-\hat{i})$
- $-48\hat{k}$

Correct: +4 · Incorrect: -1

**18** A metal coin of mass 5g and radius 1cm kxed to a thin stick AB of negligible mass as shown in the kgure. The system is initially art rest. The constant torque, that will make the system rotate about AB at 25 rotations per second in 5s, is close to




- $4.0\times10^{-6}$Nm
- $1.6\times10^{-5}$Nm
- $7.9\times10^{-6}$Nm
- $2.0\times10^{-5}$Nm

Correct: +4 · Incorrect: -1

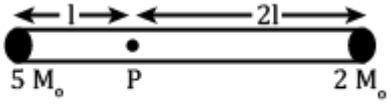
**19** The magnitude of torque on a particle of mass 1kg is 2.5 Nm about the origin. IF the force acting on it is 1N, and the distance of the particle from the origin is 5m, the angle between the force and the position vector is (in radians)

- $\frac{\pi}{6}$
- $\frac{\pi}{3}$
- $\frac{\pi}{8}$

○ $\frac{\pi}{4}$

Correct: +4 · Incorrect: -1

**20** A rigid massless rod of length 3l has two masses attached at each as shown in the kgure. The rod is pivoted at point P on the horizontal axis (see kgure). When released from initial horizontal position, its instantaneous angular acceleration will be




○ $\frac{g}{13l}$

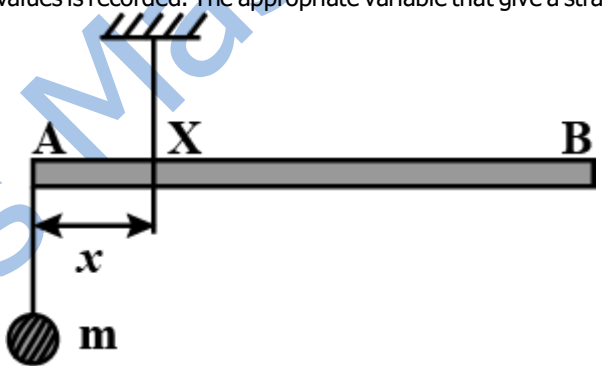
○ $\frac{g}{3l}$

○ $\frac{g}{2l}$

○ $\frac{7g}{3l}$

Correct: +4 · Incorrect: -1

**21** A uniform rod AB is suspended from point X at a variable distance from x from A as shown. To make the rod horizontal, a mass m is suspended from its end A. A set of (m, x) values is recorded. The appropriate variable that give a straight line, when plotted, are




○ m, 1/x

○ m, $1/x^2$

○ m. x

○ m, $x^2$

Correct: +4 · Incorrect: -1

Which of the following statements is false for angular momentum $\vec{L}$ about the origin?

- $\vec{L}=mv\left[\frac{R}{\sqrt{2}}+a\right]\hat{k}$ when the particle is moving from B to C.
- $\vec{L}=\frac{mv}{\sqrt{2}}R\hat{k}$ when the particle is moving from D to A
- $\vec{L}=\frac{-mv}{\sqrt{2}}R\hat{k}$ when the particle is moving from A to B
- when the particle is moving from C to D $\vec{L}=mv\left[\frac{R}{\sqrt{2}}+a\right]\hat{k}$

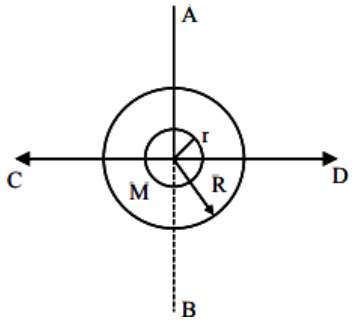
Correct: +4 · Incorrect: -1

**23** A system consists of two identical spheres each of mass 1.5kg and radius 50cm at the end of light rod. The distance between the centres of the two spheres is 5m. What will be the moment of inertia of the system abut an axis perpendicular to the rod passing through its midpoint?

- 18.75 $kgm^2$
- $1.905\times10^5$ $kgm^2$
- 19.05 $kgm^2$
- $1.875\times10^5$ $kgm^2$

Correct: +4 · Incorrect: -1

**24** The kgure shows two solid disc with radius R and r respectively,. If mass per unit area is same for both, what is the ratio of MI of bigger disc around axis AB (Which is perpendicular to the plane of the disc and passing through its centre) of MI of smaller disc around one of its diameters lying on its plane?




Given 'M' is the mass of larger disc (MI stands for moment of inertia)

- $R^2:r^2$
- $2r^4:R^4$
-

$2R^2:r^2$

○ $2R^4:r^4$

Correct: +4 · Incorrect: -1

**25** Consider a uniform wire of mass M and length L. It is bent into a semicircle. Its moment of inertia about a line perpendicular to the plane of the wire passing through the centre is

○ $\frac{2}{3}\frac{ML^2}{\pi^2}$

○ $\frac{1}{4}\frac{ML^2}{\pi^2}$

○ $\frac{1}{2}\frac{ML^2}{\pi^2}$

○ $\frac{ML^2}{\pi^2}$

Correct: +4 · Incorrect: -1

**26** Consider two uniform discs of the same thickness and different radii $R_1 = R$ and $R_2 = \alpha R$ made of the same material. If the ratio of their moments of inertia $I_1$ and $I_2$, respectively, about their axes is $I_1:I_2 = 1:16$ then the value of $\alpha$ is

○ $2\sqrt{2}$

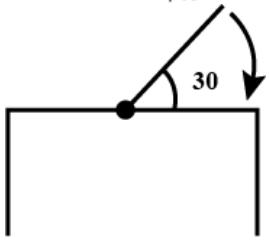
○ $\sqrt{2}$

○ 2

○ 4

Correct: +4 · Incorrect: -1

**27** One end of a straight uniform l1`m long bar is pivoted on horizontal table. It is released from rest when it makes an angle 30° from the horizontal (see kgure). Its angular speed when it hits the table is given as $\sqrt{n}\,s^{-1}$ where n is an integer. The value of n is ___




○ 5

- 10
- 15
- 20

Correct: +4 · Incorrect: -1

**28** A thin smooth rod of length L and mass M is rotating freely with angular speed $\omega_0$ about an axis is perpendicular to the rod and passing through its centre. Two beads of mass m and negligible size are at the centre of the rod initially. The beads are free to slide along the rod. The angular speed of the system, when the beads reach the opposite ends of the rod will be

- $\frac{M\omega_0}{M+m}$
- $\frac{M\omega_0}{M+3m}$
- $\frac{M\omega_0}{M+6m}$
- $\frac{M\omega_0}{M+2m}$

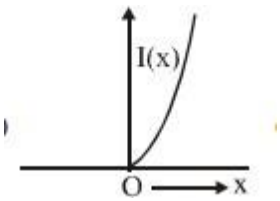
Correct: +4 · Incorrect: -1

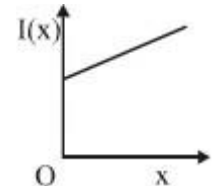
**29** Let the moment of inertia of a hollow cylinder of length 30cm (inner radius 10cm and outer radius 20cm), about its axis be 1. The radius of a thin cylinder of the same mass such that its moment of inertia about its axis is also I, is

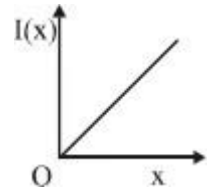
- 12cm
- 16cm
- 14cm
- 18cm

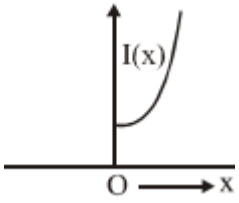
Correct: +4 · Incorrect: -1

**30** The moment of inertia of a solid sphere about an axis parallel to its diameter and at a distance of x from it, is I(x). Which one of the graphs represents the variation of I(x) and x correctly?



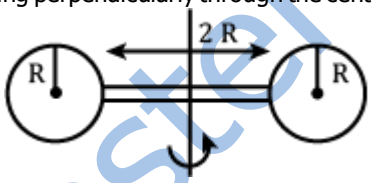



Correct: +4 · Incorrect: -1

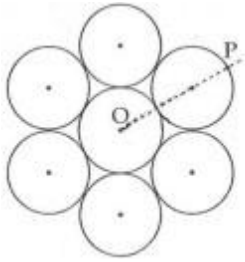
**31** Two identical spherical balls of mass M and radius R each are struck on two ends of a rod of length 2R and mass M(see kgure). The moment of inertia of the system about the axes passing perpendicularly through the centre of the rod is




- 137/15 $MR^2$
- 17/15$MR^2$
- 209/15 $MR^2$
- 152/15 $MR^2$

Correct: +4 · Incorrect: -1

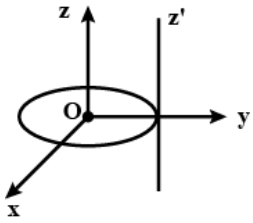
**32** Seven identical circular planar discs of mass M and radius R are welded symmetrically as shown. The moment of inertia of the arrangement about the axis normal to the plane and passing through the point P is



- 19/2 $MR^2$
- 55/2 $MR^2$
- 73/2 $MR^2$
- 181/2 $MR^2$

Correct: +4 · Incorrect: -1

**33** A thin circular disk is in the xy plane s shown in kgure. The ratio of its moment of inertia about z and z′ axes will be




- 1:2
- 1:4
- 1:3
- 1:5

Correct: +4 · Incorrect: -1

**34** The centre of wheel rolling on a plane surface moves with speed $v_0$. A particle on the rim of the wheel at the same level as the centre will be moving at a speed

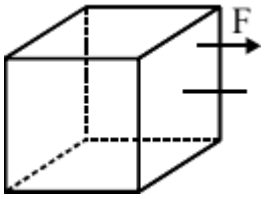
$\sqrt{x}$

$v_0$. The value of x is ___

- 1
- 2
- 3
- 4

Correct: +4 · Incorrect: -1

**35** Consider a uniform cubical box of side a on a rough floor that is to be moved by applying minimum possible force F at a point B above its centre of mass (see kgure). If the coefkcient of friction is m = 0.4, the maximum possible value of 100× b/a for box not to topple before moving is___.




- ○ 25
- ○ 50
- ○ 75
- ○ 150

Correct: +4 · Incorrect: -1

TEST

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ANSWERS

SECTIONS

1. Section A - 35 Questions

## Section 1 : Section A - 35 Questions

**1** 2

**2** 3

**3** (0.75m, 1.75m)

**4** $(R^2 + R + 1)(2 - R) = 1$

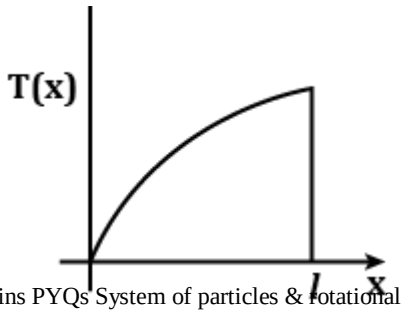
**5** 0.9cm right and 2.0cm above 1kg mass

**6** $\frac{a}{5}(\hat{i} - \hat{j})$

**7** 728

**8** $\frac{ml\omega^2}{k - m\omega^2}$

**9**



**10** 2.0

**11** $T \propto R^{(n+1)/2}$

**12** remains same in magnitude and direction

**13** $L_A$ is constant both in magnitude and direction

**14** $3\,ml^2\omega$

**15** $cos\theta = \frac{3g}{2l\omega^2}$

**16** 1 mg

**17** $-48\hat{k}$

**18** $2.0\times10^{-5}$Nm

**19** $\frac{\pi}{6}$

**20** $\frac{g}{13l}$

**21** m, 1/x

**22** $\vec{L} = mv\left[\frac{R}{\sqrt{2}} + a\right]\hat{k}$ when the particle is moving from B to C.

**23** 19.05 $kgm^2$

**24** $2R^4:r^4$

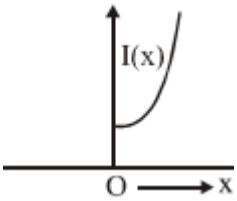
**25** $\frac{ML^2}{\pi^2}$

**26** 2

**27** 15

**28** $\frac{M\omega_0}{M+6m}$

**29** 16cm

**30** 


**31** 137/15 $MR^2$

**32** 181/2 $MR^2$

**33** 1:3

**34** 2

**35** 50

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