DPP - Daily Practice Problems

Name :

Date :

Start Time :

End Time :

PHYSICS 16

SYLLABUS : Rotational Motion-2 : Moment of inertia, radius of gyration, (values of moments of inertia simple geometrical objects)

Max. Marks : 120 **Time : 60 min.**

GENERAL INSTRUCTIONS

- The Daily Practice Problem Sheet contains 30 MCQ's. For each question only one option is correct. Darken the correct circle/ bubble in the Response Grid provided on each page.
- You have to evaluate your Response Grids yourself with the help of solution booklet.
- Each correct answer will get you 4 marks and 1 mark shall be deduced for each incorrect answer. No mark will be given/ deducted if no bubble is filled. Keep a timer in front of you and stop immediately at the end of 60 min.
- The sheet follows a particular syllabus. Do not attempt the sheet before you have completed your preparation for that syllabus. Refer syllabus sheet in the starting of the book for the syllabus of all the DPP sheets.
- After completing the sheet check your answers with the solution booklet and complete the Result Grid. Finally spend time to analyse your performance and revise the areas which emerge out as weak in your evaluation.

DIRECTIONS (Q.1-Q.21) : There are 21 multiple choice questions. Each question has 4 choices (a), (b), (c) and (d), out of which **ONLY ONE** choice is correct.

Q.1 Five particles of mass 2 kg are attached to the rim of a circular disc of radius 0.1 m & negligible mass. Moment of inertia of the system about an axis passing through the centre of the disc & perpendicular to its plane is

(a) 1 kg-m^2 (b) 0.1kg-m^2 (c) 2 kg-m^2 (d) 0.2 kg-m^2

Q.2 Two discs of the same material and thickness have radii 0.2 m and 0.6 m. Their moments of inertia about their axes will be in the ratio of

(a) 1 : 81 (b) 1: 27 (c) 1 : 9 (d) 1 : 3

Q.3 A cylinder of 500 g and radius 10 cm has moment of inertia (about its natural axis)

(a) 2.5×10^{-3} kg–m^2 (b) 2×10^{-3} kg–m^2

(c) 5×10^{-3} kg–m^2 (d) 3.5×10^{-3} kg–m^2

Q.4 A constant torque of 31.4 N–m is exerted on a pivoted wheel. If angular acceleration of wheel is 4π rad/sec^2, then the moment of inertia of the wheel is

(a) 2.5 kg–m^2 (b) 2.5 kg–m^2

(c) 4.5 kg–m^2 (d) 5.5 kg–m^2

Q.5 From a uniform wire, two circular loops are made (i) P of radius r and (ii) Q of radius nr. If the moment of inertia of loop Q about an axis passing through its centre and perpendicular to its plane is 8 times that of P about a similar axis, the value of *n* is (diameter of the wire is very much smaller than r or nr)

(a) 8 (b) 6

(c) 4 (d) 2

RESPONSE GRID	1. ⓐⓑⓒⓓ	2. ⓐⓑⓒⓓ	3. ⓐⓑⓒⓓ	4. ⓐⓑⓒⓓ	5. ⓐⓑⓒⓓ

Space for Rough Work

Q.6 The moment of inertia of a sphere of mass M and radius R about an axis passing through its centre is $\frac{2}{5}MR^2$. The radius of gyration of the sphere about a parallel axis to the above and tangent to the sphere is

(a) $\frac{7}{5}R$ (b) $\frac{3}{5}R$ (c) $\left(\sqrt{\frac{7}{5}}\right)R$ (d) $\left(\sqrt{\frac{3}{5}}\right)R$

Q.7 Four particles each of mass m are placed at the corners of a square of side length ℓ. The radius of gyration of the system about an axis perpendicular to the square and passing through its centre is

(a) $\frac{\ell}{\sqrt{2}}$ (b) $\frac{\ell}{2}$ (c) ℓ (d) $(\sqrt{2})\ell$

Q.8 The radius of gyration of a disc of mass 50 g and radius 2.5 cm, about an axis passing through its centre of gravity and perpendicular to the plane is

(a) 0.52 cm (b) 1.76 cm (c) 3.54 cm (d) 6.54 cm

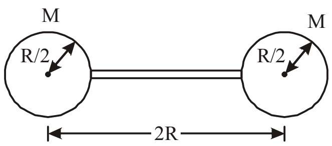
Q.9 Moment of inertia of a ring of mass m = 3 gm and radius $r = 1$ cm about an axis passing through its edge and parallel to its natural axis is

(a) 10 gm–cm^2 (b) 100 gm–cm^2
(c) 6 gm–cm^2 (d) 1 gm–cm^2

Q.10 A disc is of mass M and radius r. The moment of inertia of it about an axis tangential to its edge and in plane of the disc or parallel to its diameter is

(a) $\frac{5}{4}Mr^2$ (b) $\frac{Mr^2}{4}$ (c) $\frac{3}{2}Mr^2$ (d) $\frac{Mr^2}{2}$

Q.11 Two spheres each of mass M and radius R/2 are connected with a massless rod of length 2R as shown in the figure.



The moment of inertia of the system about an axis passing through the centre of one of the spheres and perpendicular to the rod will be

(a) $\frac{21}{5}Mr^2$ (b) $\frac{2}{5}Mr^2$ (c) $\frac{5}{2}Mr^2$ (d) $\frac{5}{21}Mr^2$

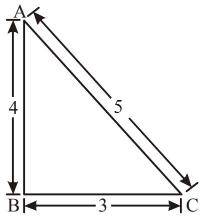
Q.12 Three point masses m_1, m_2, m_3 are located at the vertices of an equilateral triangle of length 'a'. The moment of inertia of the system about an axis along the altitude of the triangle passing through m_1, is

(a) $(m_2 + m_3)\frac{a^2}{4}$ (b) $(m_1 + m_2 + m_3)a^2$
(c) $(m_1 + m_2)\frac{a^2}{4}$ (d) $(m_2 + m_3)a^2$

Q.13 Three rods each of length L and mass M are placed along X, Y and Z axis in such a way that one end of each of the rod is at the origin. The moment of inertia of this system about Z axis is

(a) $\frac{2ML^2}{3}$ (b) $\frac{4ML^2}{3}$ (c) $\frac{5ML^2}{3}$ (d) $\frac{ML^2}{3}$

Q.14 ABC is a triangular plate of uniform thickness. The sides are in the ratio shown in the figure. I_{AB}, I_{BC}, I_{CA} are the moments of inertia of the plate about AB, BC, CA respectively. For this arrangement which one of the following relation is correct?



(a) I_{CA} is maximum (b) $I_{BC} > I_{AB}$
(c) $I_{BC} > I_{AB}$ (d) $I_{AB} + I_{BC} = I_{CA}$

Q.15 A 1m long rod has a mass of 0.12 kg. The moment of inertia about an axis passin through the centre and perpendicular to the length of rod will be

(a) 0.01kg-m^2 (b) 0.001 kg-m^2
(c) 1 kg-m^2 (d) 10 kg-m^2

Q.16 Two rings of the same radius and mass are placed such that their centres are at a common point and their planes are perpendicular to each other. The moment of inertia of the system about an axis passing through the centre and perpendicular to the plane of one of the rings is (mass of the ring = m and radius = r)

(a) $\frac{1}{2}mr^2$ (b) mr^2
(c) $\frac{3}{2}mr^2$ (d) $2\ mr^2$

RESPONSE GRID					
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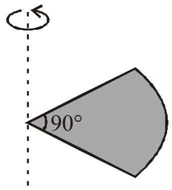
	11. ⓐⓑⓒⓓ	12. ⓐⓑⓒⓓ	13. ⓐⓑⓒⓓ	14. ⓐⓑⓒⓓ	15. ⓐⓑⓒⓓ
	16. ⓐⓑⓒⓓ				

Space for Rough Work

Q.17 One quarter sector is cut from a uniform circular disc of radius R. This sector has mass M. It is made to rotate about a line perpendicular to its plane and passing through the centre of the original disc. Its moment of inertia about the axis of rotation is



(a) $\frac{1}{2}MR^2$ (b) $\frac{1}{4}MR^2$ (c) $\frac{1}{8}MR^2$ (d) $\sqrt{2}MR^2$

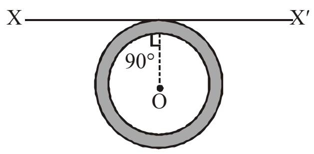
Q.18 A thin wire of length L and uniform linear mass density ρ is bent into a circular loop with centre at O as shown in figure. The moment of inertia of the loop about the axis XX′ is

(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.19 Two disc of same thickness but of different radii are made of two different materials such that their masses are same. The densities of the materials are in the ratio 1 : 3. The ratio of the moments of inertia of these discs about the respective axes passing through their centres and perpendicular to their planes will be in

(a) 1 : 3 (b) 3 : 1 (c) 1 : 9 (d) 9 : 1

Q.20 A circular disc of radius R and thickness $\frac{R}{6}$ has moment of inertia I about an axis passing through its centre and perpendicular to its plane. It is melted and recasted into a solid sphere. The moment of inertia of the sphere about one of its diameter as an axis of rotation will be

(a) I (b) $\frac{2I}{8}$ (c) $\frac{I}{5}$ (d) $\frac{I}{10}$

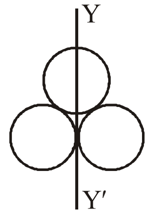
Q.21 Three rings each of mass M and radius R are arranged as shown in the figure. The moment of inertia of the system about YY' will be

(a) 3 MR^2

(b) $\frac{3}{2}MR^2$

(c) 5 MR^2

(d) $\frac{7}{2}MR^2$



DIRECTIONS (Q.22-Q.24) : In the following questions, more than one of the answers given are correct. Select the correct answers and mark it according to the following codes:

Codes :

(a) 1, 2 and 3 are correct **(b)** 1 and 2 are correct
(c) 2 and 4 are correct **(d)** 1 and 3 are correct

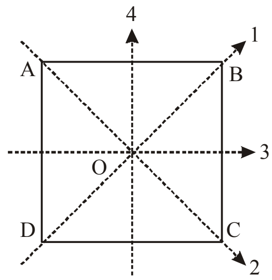
Q.22 The density of a rod AB increases linearly from A to B. Its midpoint is O and its centre of mass is at C. Four axes pass through A, B, O and C, all perpendicular to the length of the rod. The moments of inertia of the rod about these axes are I_A, I_B, I_O and I_C respectively then:.

(1) $I_A > I_B$ (2) $I_A < I_B$
(3) $I_O > I_C$ (4) $I_O < I_C$

Q.23 The moment of inertia of a thin square plate ABCD of uniform thickness about an axis passing through the centre O and perpendicular to the plane of the plate is

(1) $I_1 + I_2$
(2) $I_3 + I_4$
(3) $I_1 + I_3$
(4) $I_1 + I_2 + I_3 + I_4$

where I_1, I_2, I_3 and I_4 are respectively moments of inertia about axes 1, 2, 3 and 4 which are in the plane of the plate.



Q.24 Moment of inertia doesn't depend on

(1) distribution of particles
(2) mass
(3) position of axis of rotation
(4) None of these

RESPONSE GRID					
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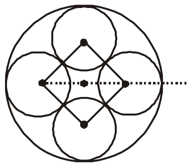
	22. ⓐⓑⓒⓓ	23. ⓐⓑⓒⓓ	24. ⓐⓑⓒⓓ		

Space for Rough Work

DIRECTIONS (Q.25-Q.27) : Read the passage given below and answer the questions that follows :



Four identical spheres having mass M and radius R are fixed tightly within a massless ring such that the centres of all spheres lie in the plane of ring. The ring is kept on a rough horizontal table as shown. The string is wrapped around the ring can roll without slipping.
The other end of the string is passed over a massless frictionless pulley to a block of mass M. A force F is applied horizontally on the ring, at the same level as the centre, so that the system is in equilibrium.

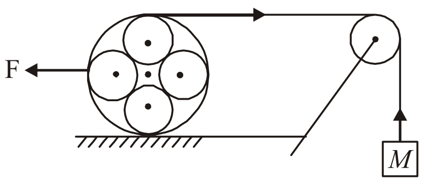
Q.25 The moment of inertia of the combined ring system about the centre of ring will be

(a) $\frac{12}{5}MR^2$

(b) $\frac{48}{15}MR^2$

(c) $\frac{24}{5}MR^2$

(d) $\frac{48}{5}MR^2$



Q.26 The magnitude of F is

(a) Mg (b) $2Mg$

(c) $\frac{Mg}{2}$ (d) None of these

Q.27 If the masses of the spheres were doubled keeping their dimensions same, the force of friction between the ring and the horizontal surface would

(a) be doubled
(b) increase but be less than double
(c) remain the same
(d) decrease

DIRECTIONS (Q. 28-Q.30) : Each of these questions contains two statements: Statement-1 (Assertion) and Statement-2 (Reason). Each of these questions has four alternative choices, only one of which is the correct answer. You have to select the correct choice.

(a) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(b) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1.
(c) Statement-1 is False, Statement-2 is True.
(d) Statement-1 is True, Statement-2 is False.

Q.28 **Statement-1 :** Radius of gyration of a body is a constant quantity.
Statement-2 : The radius of gyration of a body about an axis of rotation may be defined as the root mean square distance of the particles of the body from the axis of rotation.

Q.29 **Statement-1 :** Moment of inertia of a particle is same, whatever be the axis of rotation.
Statement-2 : Moment of inertia depends on mass and perpendicular distance of the particle from its axis of rotation.

Q.30 **Statement-1 :** If earth shrink (without change in mass) to half of its present size, length of the day would become 6 hours.
Statement-2 : When the size of the earth will change, its moment of inertia will also change.

RESPONSE GRID	
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DAILY PRACTICE PROBLEM SHEET 16 - PHYSICS

Total Questions	30	Total Marks	120
Attempted		Correct	
Incorrect		Net Score	
Cut-off Score	32	Qualifying Score	50
Success Gap = Net Score – Qualifying Score			
Net Score = (Correct × 4) – (Incorrect × 1)			

Space for Rough Work

DAILY PRACTICE PROBLEMS

PHYSICS SOLUTIONS

16

(1) (b) As the mass of disc is negligible therefore only moment of inertia of five particles will be considered.

$I = \sum mr^2 = 5\ mr^2 = 5 \times 2 \times (0.1)^2 = 0.1$ kg-m^2

(2) (a) $I = \frac{1}{2}MR^2 = \frac{1}{2}\times\left(\pi R^2 t \times p\right)\times R^2$

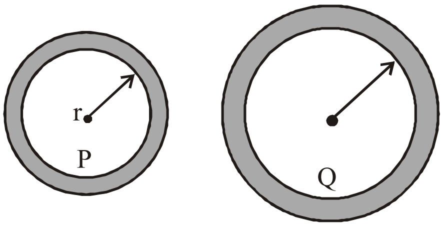
$\Rightarrow I \propto R^4$ (As t and p are same)

$\therefore \frac{I_1}{I_2} = \left(\frac{R_1}{R_2}\right)^4 = \left(\frac{0.2}{0.6}\right)^4 = \frac{1}{81}$

(3) (a) $I = \frac{1}{2}MR^2 = \frac{1}{2}\times 0.5\times(0.1)^2 = 2.5\times10^{-3}\,kg-m^2$

(4) (a) $I = \frac{\tau}{\alpha} = \frac{31.4}{4\pi} = 2.5 kg\, m^2$

(5) (d) Let the mass of loop P (radius = r) = m
So the mass of loop Q (radius = nr) = nm



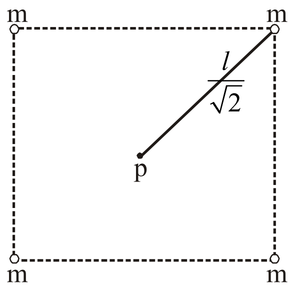
Moment of inertia of loop P, $I_P = mr^2$
Moment of inertia of loop Q. $I_Q = nm\,(nr)^2 = n^3\,mr^2$

$\therefore \frac{I_Q}{I_P} = n^3 = 8 \Rightarrow n = 2$

(6) (c) Moment of inertia of sphere about its tangent

$\frac{7}{5}MR^2 = MK^2 \Rightarrow K = \sqrt{\frac{7}{5}}R$

(7) (a) Moment of inertia of system about point P



$= 4m\left(\frac{l}{\sqrt{2}}\right)^2 = 2ml^2$ and $4mK^2 = 2ml^2$

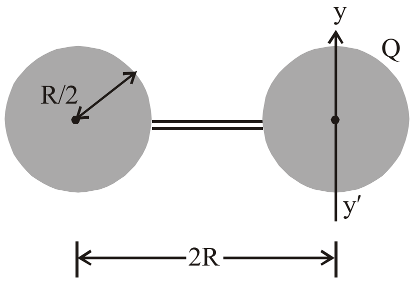
$\therefore K = \frac{l}{\sqrt{2}}$

(8) (b) $\frac{1}{2}MR^2 = MK^2 \Rightarrow K = \frac{R}{\sqrt{2}} = \frac{2.5}{\sqrt{2}} = 1.76\,\text{cm}$

(9) (c) $I = 2MR^2 = 2 \times 3 \times (1)^2 = 6$ gm-cm^2

(10) (a) $I = \frac{5}{4}Mr^2$

(11) (a)



Moment of inertia of the system about yy′
$I_{yy'}$ = Moment of inertia of sphere P about yy′ + Moment of inertia of sphere Q about yy′
Moment of inertia of sphere P about yy′

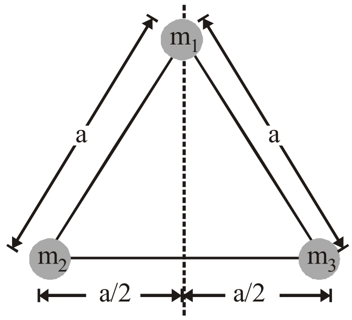
$= \frac{2}{5}M\left(\frac{R}{2}\right)^2 + M(x)^2$ [Parallel axis theorem]

$= = \frac{2}{5}M\left(\frac{R}{2}\right)^2 + M(2R)^2 = \frac{MR^2}{10} + 4MR^2$

Moment of inertia of sphere Q about yy′ is $\frac{2}{5}M\left(\frac{R}{2}\right)^2$

Now $I_{yy'} = \frac{MR^2}{10} + 4MR^2 + \frac{2}{5}M\left(\frac{R}{2}\right)^2 = \frac{21}{5}MR^2$

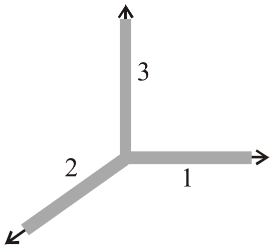
(12) (a) M.I. of system about the axis which passing through m_1



$I_{system} = m_1\,(0)^2 + m_2\left(\frac{a}{2}\right)^2 + m_3\left(\frac{a}{2}\right)^2$

$I_{system} = (m_2 + m_3)\frac{a^2}{4}$

(13) (a) M.I. of rod (1) about Z – axis $I_1 = \frac{Ml^2}{3}$



M.I. of rod (2) about Z-axis, $I_2 = \frac{Ml^2}{3}$

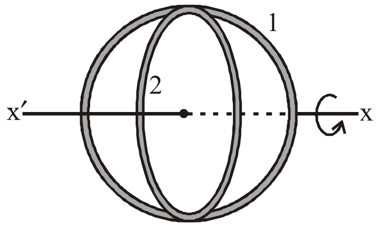
M.I. of rod (3) about Z – axis, $I_3 = 0$
Because this rod lies on Z-axis

$\therefore \quad I_{system} = I_1 + I_2 + I_3 = \frac{2Ml^2}{3}$

(14) (c) Distribution of mass about BC axis is more than that about AB axis i.e. radius of gyration about BC axis is more than that about AB axis.
i.e. $K_{BC} > K_{AB} \therefore I_{BC} > I_{AB} > I_{CA}$

(15) (a) $I = \frac{Ml^2}{12} = \frac{0.12 \times 1^2}{12} = 0.01 kg - m^2$

(16) (c)



I_1 = M.I. of ring about its diameter $= \frac{1}{2}mR^2$

I_2 = M.I. of ring about the axis normal to plane and passing through centre $= mR^2$
Two rings are placed according to figure. Then

$I_{xx'} = I_1 + I_2 = \frac{1}{2}mR^2 + mR^2 = \frac{3}{2}mR^2$

(17) (a) Mass of the centre disc would be 4M and its moment of inertia about the given axis would be $\frac{1}{2}(4M)R^2$.
For the given section the moment of inertia about the same axis would be one quarter of this i.e. $\frac{1}{2}MR^2$.

(18) (d) Mass per unit length of the wire = ρ
Mass of L length, M = ρL
and since the wire of length L is bent in a or of circular loop therefore $2\pi R = L \Rightarrow R = \frac{L}{2\pi}$

Moment of inertia of loop about given axis $= \frac{3}{2}MR^2$

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

(19) (b) M.I. of disc $= \frac{1}{2}MR^2 = \frac{1}{2}M\left(\frac{M}{\pi t\rho}\right) = \frac{1}{2}\frac{M^2}{\pi t\rho}$

$\left(\text{As } \rho = \frac{M}{\pi R^2 t} \text{ Therefore } R^2 = \frac{M}{\pi t\rho}\right)$

If mass and thickness are same then, $I \propto \frac{1}{\rho}$

$\therefore \frac{I_1}{I_2} = \frac{\rho_2}{\rho_1} = \frac{3}{1}.$

(20) (c) According to problem disc is melted and recasted into a solid sphere so their volume will be same.

$V_{Disc} = V_{Sphere} \Rightarrow \pi R_{Disc}^2 t = \frac{4}{3}\pi R_{Sphere}^3$

$\Rightarrow \pi R_{Disc}^3\left(\frac{R_{Disc}}{6}\right) = \frac{4}{3}\pi R_{Sphere}^3 \quad \left[t = \frac{R_{Disc}}{6}, \text{given}\right]$

$\Rightarrow R_{Disc}^3 = 8R_{Sphere}^3 \Rightarrow R_{Sphere} = \frac{R_{Disc}}{2}$

Moment of inertia of disc

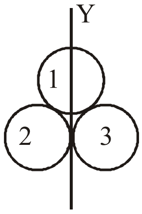
$I_{Disc} = \frac{1}{2}MR_{Disc}^2 = I \text{ (given)}$

$\therefore M(R_{Disc})^2 = 2I$

Moment of inertia of sphere $I_{sphere} = \frac{2}{5}MR_{Sphere}^2$

$= \frac{2}{5}M\left(\frac{R_{Disc}}{2}\right)^2 = \frac{M}{10}(R_{Discs})^2 = \frac{2I}{10} = \frac{1}{5}$

(21) (d) Moment of inertia of system about YY'
$I = I_1 + I_2 + I_3$



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

$= \frac{7}{2}MR^2$

(22) (d) As C is the centre of mass, so, I_C will be minimum. Also more mass is towards B so $I_A > I_B$.

(23) (a) Applying the theorem of perpendicular axis,
$I = I_1 + I_2 = I_3 + I_4$
Because of symmetry, we have $I_1 = I_2$ and $I_3 = I_4$ Hence
$I = 2I_1 = 2I_2 = 2I_3 = 2I_4$ or $I_1 = I_2 = I_3 = I_4$
i.e. sum of two moment of inertia of square plate about any axis in a plane (Passing through centre) should be equal to moment of inertia about the axis passing through the centre and perpendicular to the plane of the plate.

(24) (d) Moment of inertia depends on all the three factors given in (1), (2) & (3).

(25) (d) $I = 4\left[\frac{2}{5}MR^2 + M(R\sqrt{2})^2\right]$

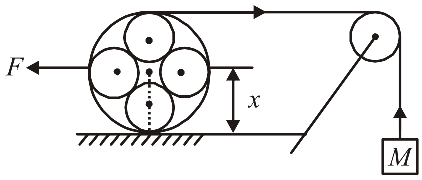
$= 4MR^2\left[\frac{2}{5} + 2\right]$

$= \frac{4MR^2 \times 12}{5} = \frac{48MR^2}{5}$.

(26) (b) Let a be the acceleration of centre of mass

$Mg - T = 0$ ... (i)

$F.x = T.2x$ ... (ii)



(27) (c) remain the same

(28) (c) Radius of gyration of a body is not a constant quantity. Its value changes with the change in location of the axis of rotation. Radius of gyration of a body about a given axis is given as $K = \sqrt{\frac{r_1^2 + r_2^2 + ... + r_n^2}{n}}$

(29) (c) The moment of inertia of a particle about an axis of rotation is given by the product of the mass of the particle and the square of the perpendicular distance of the particle from the axis of rotation. For different axis, distance would be different, therefore moment of inertia of a particle changes with the change in axis of rotation.

(30) (a) When earth shrinks, it angular momentum remains constant. i.e. $L = I\omega = \frac{2}{5}mR^2 \times \frac{2\pi}{T} =$ constant.

$\therefore T \propto I \propto R^2$. It means if size of the earth changes then its moment of inertia changes.

In the problem radius becomes half so time period (Length of the day) will becomes $\frac{1}{4}$ of the present value

i.e. $\frac{24}{4} = 6\,\text{hr}$.