PHYSICS

BOOKS - DISHA PUBLICATION PHYSICS (HINGLISH)

SYSTEM OF PARTICLES & ROTATIONAL MOTION

Jee Main 5 Years At A Glance

1. A force of 40 N acts on a point B at the end of an L-shaped object, as shown in the figure. The angle θ that will produce maximum moment of the force about point A is given by:

A. $\tan\theta = \frac{1}{4}$

B. $\tan\theta = 2$

C. $\tan\theta = \frac{1}{2}$

D. $\tan\theta = 4$

Answer: C

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2. A thin circular disk in the xy plane as shown in the figure.

The ratio of its moment of inertia about z and z' axes will be

A. $1:2$

B. $1:4$

C. $1:3$

D. $1:5$

Answer: C

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3. A uniform rod AB is suspended from a 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:

A. $m, \frac{1}{x}$

B. $m, \frac{1}{x^2}$

C. m, x

D. m, x^2

Answer: A

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4. A thin rod MN, free to rotate in the vertical plane about the fixed end N, is held horizontal. When the end M is released the speed of this end, when the rod makes an angle α with the horizontal, will be proportional to:

A. $\sqrt{\cos \alpha}$

B. $\cos \alpha$

C. $\sin \alpha$

D. $\sqrt{\sin \alpha}$

Answer: A

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5. A particle is moving with a uniform speed in a circular orbit of radius R in a central force inversely proportional to the n^{th} power of R. If the period of rotation of the particle is T, then :

A. $T \propto R^{3/2}$ for any n

B. $T \propto R^{n/2+1}$

C. $T \propto R^{(n+1)/2}$

D. $T \propto R^{n/2}$

Answer: C

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6. Seven identical circular planar disks, each 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:

A. $\frac{19}{2}MR^2$

B. $\frac{55}{2}MR^2$

C. $\frac{73}{2}MR^2$

D. $\frac{181}{2}MR^2$

Answer: D

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7. In a physical balance working on the principle of moments, when 5 mg weight is placed on the left pan, the beam becomes horizontal. Both the empty pans of the balance are of equal mass. Which of the following statements is correct ?

A. Left arm is longer than the right arm

B. Both the arms are of sae length

C. Left arm is shorter than the right arm

D. Every object that is weighed using this balance appears lighter than its actual weight.

Answer: C

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8. The moment of inertia of a uniform cylinder of length l and $radius R$ about its perpendicular bisector is I. What is the ratio

l/R such that the moment of inertia is minimum ?

A. 1

B. $\frac{3}{\sqrt{2}}$

C. $\sqrt{\frac{3}{2}}$

D. $\frac{\sqrt{3}}{2}$

Answer: C

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9. A cubical block of side 30 cm is moving with velocity $2ms^{-1}$ on a smooth horizontal surface. The surface has a bump at a point O as shown in figure. The angular velocity (in rad/s) of the block immediately after it hits the bump, is :

A. 13.3

B. 5.0

C. 9.4

D. 6.7

Answer: B

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10. A roller is made by joining together two cones at their vertices O. It is kept on two rails AB and CD, which are placed asymmetrically with its axis perpendicular to CD and its centre O at the centre of line joining AB and Cd. It is given a light push so that it starts rolling with

its centre O moving parallel to CD in the direction shown. As it moves, the roller will tend to:

A. go straight

B. turn left and right alternately

C. turn left

D. turn right

Answer: C

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11. A particle of mass 2 kg is on a smooth horizontal table and moves in a circular path of radius 0.6 m. The height of the table from the ground is 0.8 m. If the angular speed of the particle is $12\,\mathrm{rad\,s^{-1}}$, the magnitude of its angular momentum about a point on the ground right under the centre of the circle is

A. $14.4kgm^2s^{-1}$

B. $8.64kgm^2s^{-1}$

C. $20.16kgm^2s^{-1}$

D. $11.52 kgm^2 s^{-1}$

Answer: A

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12. A uniform solid cylindrical roller of mass 'm' is being pulled on a horizontal surface with force F parallel to the surface and applied at its centre. If the acceleration of the cylinder is 'a' and it is rolling without slipping, then the value of 'F' is : $-$

A. ma

B. $\frac{5}{3}$ ma

C. $\frac{3}{2}$ ma

D. 2 ma

Answer: C

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13. Distance of the centre of mass of a solid uniform cone from its vertex is z_0 . If the

radius of its base is R and its height is h then

z_0 is equal to:

A. $\frac{5h}{8}$

B. $\frac{3h^2}{8R}$

C. $\frac{h^2}{4R}$

D. $\frac{3h}{4}$

Answer: D

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14. From a solid sphere of M and radius R a cube of maximum possible volume is cut. Moment of inertia of cube about an axis passing through its centre and perpendiular to one of its faces is:

A. $\frac{4MR^2}{9\sqrt{3}\pi}$

B. $\frac{4MR^2}{3\sqrt{3}\pi}$

C. $\frac{MR^2}{32\sqrt{2}\pi}$

D. $\frac{MR^2}{16\sqrt{2}\pi}$

Answer: A

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15. A ball of mass 160 g is thrown up at an angle of 60° to the horizontal at a speed of $10ms^{-1}$. The angular momentum of the ball at the highest point of the trajectory with respect to the point from which the ball is thrown is nearly $(g = 10ms^{-2})$

A. $1.73kgm^2/s$

B. $3.0kgm^2/s$

C. $3.46kgm^2/s$

D. $6.0 kgm^2 / s$

Answer: B

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16. A bob of mass m attached to an inextensible string of length I is suspended from a vertical support. The bob rotates in a horizontal circle with an angular speed ω red/s about the vertical. About the point of suspension:

A. angular momentum is conserved

B. angular momentum changes in magnitude but not in direction

C. angular momentum changes in direction but not in magnitude

D. angular momentum changes both in direction and magnitude.

Answer: C

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Exercise 1 Concept Builder

1. A shell following a parabolic path explodes somewhere in its flight. The centre of mass of fragements will move in

A. vertical direction

B. any direction

C. horizontal direction

D. same parabolic path

Answer: D

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2. Two particles of mass m_1 and $m_2(m_1 > m_2)$ attract each other with a force inversely proportional to the square of the distance between them. If the particles are initially held at rest and then released, the centre of mass will

A. move towards m_1

B. move towards m_2

C. remains at rest

D. None of these

Answer: C

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3. The mass per unit length of a non-uniform rod of length L is given by $\mu = \lambda \times 2$, where λ is a constant and x is distance from one end of the rod. The distance of the center of mass of rod from this end is :-

A. $\frac{2}{3}L$

B. $\frac{3}{2}L$

C. $\frac{1}{2}L$

D. $\frac{4}{3}L$

Answer: A

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4. A wheel rotates with a constasnt acceleration of $2.0ra\frac{d}{s^2}$. If the wheel starts from rest, how many evolutions wil it make in the first 10 senconds?

A. 8

B. 16

C. 24

D. 32

Answer: B

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5. Two bodies A and B have masses M and m respectively where $M > m$ and they are at a distance d apart. Equal force is

applied to each of them so that they approach each other. The position where they hit each other is :

A. nearer to B

B. nearer to A

C. at equal distance from A and B

D. cannot be determined

Answer: B

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6. A pulley fixed to the ceiling carries a string with blocks of mass m and $3m$ attached to its ends. The masses of string and pulley are negligible .When the system is released, its center of mass moves with what acceleration

A. 0

B. $-g/4$

C. $g/2$

D. $-g/2$

Answer: C

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7. The wheel of a car is rotating at the rate of 1200 revolutions per minute. On pressing the accelerator for 10 seconds, it starts rotating at 4500 revolutions per minute. The angular acceleration of the wheel is

A. 30 radian/second^2

B. 1880 degree/second^2

C. 40 radian/second^2

D. 1980 degree/second^2

Answer: D

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8. Three identical spheres, each of mass 1 kg are kept as shown in figure, touching each other, with their centres on a straight line. If their centres are marked

P,Q,R respectively, the distance of centre of mass of the system from P is

A. $\frac{PQ + PR + QR}{3}$

B. $\frac{PQ + PR}{3}$

C. $\frac{PQ + QR}{3}$

D. $\frac{PR + QR}{3}$

Answer: B

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9. When a celling fan is switched off, its angular velocity falls to half while it makes 36

rotations. How many more rotations will it make before coming to rest ?

A. 24

B. 36

C. 18

D. 12

Answer: D

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10. The position Vectors of two identical particles with respect to the origin in the three-dimensional coordinator system are r_1 and r_2 The position of the centre of mass of the system is given by

A. $\vec{x} - \vec{y}$

B. $\frac{\vec{x} + \vec{y}}{2}$

C. $\left(\vec{x} - \vec{y}\right)$

D. $\frac{\vec{x} - \vec{y}}{2}$

Answer: B

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11. In a bicycle the radius of rear wheel is twice the radius of front wheel. If v_F and v_r are the speeds of top most points of front and rear wheels respectively, then :

A. $v_r = 2v_f$

B. $v_f = 2v_r$

C. $v_f = v_r$

D. $v_f = 4v_r$

Answer: C

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12. In a carbon monoxide molecule, the carbon and the oxygen atoms are separted by a distance 1.12×10^{10} m. The distance of the centre of mass from the carbon atom is

A. $0.64 \times 10^{-10} m$

B. $0.56 \times 10^{-10} m$

C. $0.51 \times 10^{-10} m$

D. $0.48 \times 10^{-10} m$

Answer: A

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13. Two paricle A and B initially at rest, move towards each other under mutual force of attraction. At the instant when the speed of A is V and the speed of B is 2V, the speed of the centre of mass of the system is

A. 2v

B. v

C. 1.5 v

D. zero

Answer: D

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14. Five masses are placed in a plane as shown in figure. The coordinates of the centre of mass are nearest to

A. $1.2, 1.4$

B. $1.3, 1.1$

C. $1.1, 1.3$

D. $1.0, 1.0$

Answer: C

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15. A small disc of radius 2cm is cut from a disc of radius 6cm. If the distance their centers is

3.2cm, what is the shift in the center of mass of the disc?

A. 0.4 cm

B. 2.4 cm

C. 1.8 cm

D. 1.2 cm

Answer: A

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16. The angular momentum of a system of particles is conserved

A. when no external force acts upon the system

B. when no external torque acts upon the system

C. when no external impulse acts upon the system

D. when axis of rotation remains same

Answer: B

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17. ABC is an equilateral triangle with O as its centre. $\vec{F}_1, \vec{F}_2$ and $\vec{F}_3$ represent three force acting along the sides AB, BC and AC respectively. If the total torque about O is zero the magnitude of $\vec{F}_3$ is :

A. $F_1 + F_2$

B. $F_1 - F_2$

C. $\frac{F_1 + F_2}{2}$

D. $2(F_1 + F_2)$

Answer: A

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18. A particle of mass m is moving in a plane along a circular path of radius r. Its angular momentum about the axis of rotation is L. The centripetal force acting on the particle is.

A. L^2/mr

B. L^2m/r

C. L^2/mr^3

D. L^2/mr^2

Answer: C

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19. A stone of mass ied to a string of lengh l rotating along & a circular path with constant speed v. The torque on the stone is

A. m/v

B. mv/l

C. mv^2/l

D. zero

Answer: B

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20. A force of $-F\vec{k}$ acts on O, the origin of the coordinate system. The torque about the

point $(1, -1)$ is

A. $F\left(\hat{i}-\hat{j}\right)$

B. $-F\left(\hat{i}+\hat{j}\right)$

C. $F\left(\hat{i}+\hat{j}\right)$

D. $-F\left(\hat{i}-\hat{j}\right)$

Answer: C

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21. A particle of mass 0.2 kg is moving in a circle of radius 1 m with $f = (2/\pi)\sec^{-1}$, then its angular momentum is :

A. $0.8kg - m^2/s$

B. $2kg - m^2/s$

C. $8kg - m^2/s$

D. $16kg - m^2/s$

Answer: A

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22. A man stands in the middle of a rotating table which has an angular velocity ω He is holding two equal masses at arms lengtii ineach hand. Without moving his arms he just drops the two masses. How will be the angular speed of table get changed?

A. increase

B. decrease

C. become zero

D. remain constant

Answer: A

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23. A wheel having moment of inertia $2kgm^2$ about its vertical axis, rotates at the rate of $60r \pm$ about this axis. The torque which can stop the wheel's rotation in one minute would be

A. $\frac{\pi}{18}Nm$

B. $\frac{2\pi}{15}Nm$

C. $\frac{\pi}{12} Nm$

D. $\frac{\pi}{15} Nm$

Answer: D

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24. A smooth sphere A is moving on a frictionless horizontal plane with angular speed ω and centre of mass velocity v. It collides elastically and head on with an identical sphere B at rest. Neglect friction

everywhere. After the collision, their angular speeds are ω_A and ω_B respectively. Then

A. $\omega_A < \omega_B$

B. $\omega_A = \omega_B$

C. $\omega_A = \omega$

D. $\omega_B = \omega$

Answer: C

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25. A particle of mass m is moving in a circle of radius r. The centripetal acceleration (a_c) of the particle varies with the time according to the relation, $a_c = Kt^2$, where K is a positive constant and t is the time. The magnitude of the time rate of change of angular momentum of the particle about the centre of the circle is

A. mKr

B. $\sqrt{m^2Kr^3}$

C. $\sqrt{mKr}$

D. mKr^2

Answer: B

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26. A particle of mass 2 kg is moving such that at time t, its position, in meter, is given by $\overrightarrow{r}(t) = 5\hat{i} - 2t^2\hat{j}$. The angular momentum of the particle at t = 2s about the origin in kg $m^{-2}s^{-1}$ is :

A. $-80\hat{k}$

B. $\left(10\hat{i} - 16\hat{j}\right)$

C. $-40\hat{k}$

D. $40\hat{k}$

Answer: A

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27. A bullet of mass $10g$ and speed $500m/s$ is fired into a door and gets embedded exactly at the centre of the door. The door is $1.0m$ wide and weight $12kg$. It is hinged at one end and

rotates about a vertical axis practically without friction. Find the angular speed of the door just after the bullet embeds into it.(Hint. The moment of inertia of the door about the vertical axis at one end is $ML^2/3)$

A. 6.25 rad/sec

B. 0.625 rad/sec

C. 3.35 rad/sec

D. 0.335 rad/sec

Answer: B

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28. A stone of mass m tied to the end of a string, is whirled around in a horizontal circle. (Neglect the force due to gravity). The length of the string is reduced gradually keeping the angular momentum of the stone about the centre of the circle constant. Then, the tension in the string is given by $T = Ar^n$ where A is a constant, r is the instantaneous radius of the circle and n=....

A. -1

B. -2

C. -4

D. -3

Answer: D

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29. A flywheel rotates about an axis. Due to friction at the axis, it experiences an angular retardation proportional to its angular velocity. If its angular velocity falls to half while

it makes n rotations, how many more rotations will it make before coming to rest?

A. 2n

B. n

C. $n/2$

D. $n/3$

Answer: B

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30. The curve between $\log_e$ L and $\log_e$ P is (L is the angular momentum and P is the linear momentum).

A. 

B. 

C. 

D. 

Answer: B

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31. The angular momentum of a particle relative to a certain point O varies with time as $M = a + bt^2$, where a and b are constant vectors, with $a \perp b$. Find the force moment N relative to the point O acting on the particle when the angle between the vectors N and M equals 45°.

A. $\sqrt{\frac{a}{b}}$

B. $2\sqrt{\frac{a}{b}}$

C. $2b\sqrt{\frac{a}{b}}$

D. $2a\sqrt{\frac{b}{a}}$

Answer: C

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32. Moment of inertia of a disc about an axis which is tangent and parallel to its plane is I . Then the moment of inertia of disc about a tangent, but perpendicular to its plane will be

A. $\frac{6}{5}I$

B. $\frac{3}{4}I$

C. $\frac{3}{2}I$

D. $\frac{5}{4}I$

Answer: B

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33. A circular turn table has a block of ice placed at its centre. The system rotates with an angular speed w about an axis passing through the centre of the table. If the ice

melts on its own without any evaporation, the speed of rotation of the system

A. becomes zero

B. remains constant at the same value ω

C. increases to a value greater than ω

D. decrease to a value less than ω

Answer: D

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34. A rod of mass m and length l is bent in to shape of L. Its moment of inertia about the axis shown in figure

A. $\frac{ml^2}{6}$

B. $\frac{ml^2}{3}$

C. $\frac{ml^2}{2}$

D. None

Answer: A

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35. Consider a uniform square plate of side 'a' and mass 'm'. The moment of inertia of this plate about an axis perpendicular to its plane and passing through one of its corners is

A. $\frac{5}{6}Ma^2$

B. $\frac{1}{12}Ma^2$

C. $\frac{7}{12}Ma^2$

D. $\frac{2}{3}Ma^2$

Answer: D

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36. The angular speed of a body changes from ω_1 to ω_2 without applying a torque but due to change in its moment of inertia. The ratio of radii of gyration in the two cases is :-

A. $\omega_1 : \omega_2$

B. $\sqrt{\omega_1} : \sqrt{\omega_2}$

C. $\omega_2 : \omega_1$

D. $\sqrt{\omega_2} : \sqrt{\omega_1}$

Answer: D

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37. Three particles, each of mass m gram, are situated at the vertices of an equilateral triangle ABC of side l cm (as shown in the figure). The moment of inertia of the system about a line AX perpendicular to AB and in the

plane of ABC, in gram-cm^2 units will be

A. $\frac{3}{2}ml^2$

B. $\frac{3}{4}ml^2$

C. $2ml^2$

D. $\frac{5}{4}ml^2$

Answer: D

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38. Of the two eggs which have identical sizes, shapes and weights, one is raw and other is half boiled. The ratio between the moment of inertia of the raw to the half boiled egg about central axis is:

A. one

B. greater than one

C. less than one

D. not comparable

Answer: B

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39. A billiard ball of mass m and radius r, when hit in a horizontal direction by a cue at a height h above its centre, acquired a linear velocity v_0. The angular velocity ω_0 acquired by the ball is

A. $\frac{5v_0r^2}{2h}$

B. $\frac{2v_0r^2}{5h}$

C. $\frac{2v_0h}{5r^2}$

D. $\frac{5v_0h}{2r^2}$

Answer: D

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40. The moment of inertia of a disc of mass M and radius R about an axis. Which is tangential to sircumference of disc and parallel to its diameter is.

A. $\frac{3}{2}MR^2$

B. $\frac{2}{3}MR^2$

C. $\frac{5}{4}MR^2$

D. $\frac{4}{5}MR^2$

Answer: C

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41. Find the moment of inertia of a uniform square plate of mass M and edge a about one of its diagonals.

A. $I > \frac{ma^2}{12}$

B. $\frac{ma^2}{24} < I < \frac{ma^2}{12}$

C. $I = \frac{ma^2}{24}$

D. $I = \frac{ma^2}{12}$

Answer: D

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42. Moment of inertia of a uniform circular disc about a diameter is I. Its moment of inertia about an axis perpendicular to its

plane and passing through a point on its rim will be.

A. 5I

B. 3I

C. 6I

D. 4I

Answer: C

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43. A circular disc X of radius R is made from an iron plate of thickness t, and another disc Y of radius 4R is made from an iron plate of thickness $\frac{t}{4}$. Then the relation between the moment of inerita I_X and I_Y is

A. $I_Y = 32I_X$

B. $I_Y = 16I_X$

C. $I_Y = I_X$

D. $I_Y = 64I_X$

Answer: D

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44. Point masses $1, 2, 3 \text{and} 4kg$ are lying at the point $(0, 0, 0), (2, 0, 0), (0, 3, 0)$ and $(-2, -2, 0)$ respectively. The moment of inertia of this system about x-axis will be

A. $43kgm^2$

B. $34kgm^2$

C. $27kgm^2$

D. $72kgm^2$

Answer: A

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45. For the given uniform square lamina ABCD, whose centre is O,

A. $I_{AC} = \sqrt{2} I_{EF}$

B. $\sqrt{2} I_{AC} = I_{EF}$

C. $I_{AD} = 3 I_{EF}$

D. $I_{AC} = I_{EF}$

Answer: D

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46. Initial angular velocity of a circular disc of mass M is ω_1. Then two small spheres of mass m are attached gently to two diametrically opposite points on the edge of the disc. What is the final angular velocity of the disc -

A. $\left(\frac{M+m}{M}\right)\omega_1$

B. $\left(\frac{M+m}{m}\right)\omega_1$

C. $\left(\frac{M}{M+4m}\right)\omega_1$

D. $\left(\frac{M}{M+2m}\right)\omega_1$

Answer: C

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47. A loop rolls down on an inclined plane. The fraction of its kinetic energy that is associated with only the rotational motion is.

A. $1:2$

B. $1:3$

C. $1:4$

D. $2:3$

Answer: A

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48. A rod PQ of length L revolves in a horizontal plane about the axis YY′. The angular velocity of the rod is w. If A is the area

of cross-section of the rod and ρ be its density,

its rotational kinetic energy is

A. $\frac{1}{3}AL^3\rho\omega^2$

B. $\frac{1}{2}AL^3\rho\omega^2$

C. $\frac{1}{24}AL^3\rho\omega^2$

D. $\frac{1}{18}AL^3\rho\omega^2$

Answer: C

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49. A ball rolls without slipping. The radius of gyration of the ball about an axis passing through its centre of mass is k. If radius of the ball be R, then the fraction of total energy associated with its rotation will be.

A. $\frac{K^2}{R^2}$

B. $\frac{K^2}{K^2 + R^2}$

C. $\frac{R^2}{K^2 + R^2}$

D. $\frac{K^2 + R^2}{R^2}$

Answer: B

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50. A solid sphere rolls on a smooth horizontal surface at $10m/s$ and then rolls up a smooth inclined plane of inclination 30° with horizontal. The mass of the sphere is $2kg$. Find the height attained by the sphere before it stops (in m).

A. 700 cm

B. 701 cm

C. 7.1 m

D. None of these

Answer: C

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51. A solid cylinder of mass m & radius R rolls down inclined plane without slipping. The speed of its C.M. when it reaches the bottom is

A. $\sqrt{2gh}$

B. $\sqrt{4gh/3}$

C. $\sqrt{3/4gh}$

D. $\sqrt{4gh}$

Answer: D

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52. The least coefficient of friction for an inclined plane inclined at angle α with horizontal in order that a solid cylinder will roll down without slipping is

A. $\frac{2}{3}\tan\alpha$

B. $\frac{2}{7}\tan\alpha$

C. $\tan\alpha$

D. $\frac{5}{7}\tan\alpha$

Answer: C

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53. A tangential force of 20 N is applied on a cylinder of mass 4 kg and moment of inertia $0.02kgm^2$ about its own axis. If the cylinder

rolls without slipping, then linear acceleration of its centre of mass will be

A. $6.7m/s^2$

B. $10m/s^2$

C. $3.3m/s^2$

D. None of these

Answer: A

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54. A body of moment of inertia about its axis of rotation is $3kgm^2$ and angular velocity 3 rad/s. The kinetic energy of rotating body is same as that of body of mass 27 kg moving with a speed of

A. $1.0m/s$

B. $0.5m/s$

C. $1.5m/s$

D. $2.0m/s$

Answer: A

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55. A toy car rolls down the inclined plane as shown in the fig. It loops at the bottom. What is the relation between H and h?

A. $\frac{H}{h} = 2$

B. $\frac{H}{h} = 3$

C. $\frac{H}{h} = 4$

D. $\frac{H}{h} = 5$

Answer: D

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56. The moment of inertia of the body about an axis is 1.2 kg m^2. Initially the body is at rest. In order to produce a rotational kinetic energy of 1500J, an angualr acceleration of 25 $ra\frac{d}{s^2}$ must be applied about the axis for the duration of

A. 4 seconds

B. 2 seconds

C. 8 seconds

D. 10 seconds

Answer: B

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57. A uniform rod of length l is free to rotate in a vertical plane about a fixed horizontal axis through O. The rod begins rotating from rest from its unstable equilibrium position. When

it has turned through an angle θ, its angular velocity ω is given as

A. $\sqrt{\frac{6g}{l}}\sin\theta$

B. $\sqrt{\frac{6g}{l}}\sin.\frac{\theta}{2}$

C. $\sqrt{\frac{6g}{l}}\cos.\frac{\theta}{2}$

D. $\sqrt{\frac{6g}{l}}\cos\theta$

Answer: C

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58. A cord is wound round the circumference of wheel of radius r. The axis of the wheel is horizontal and fixed and moment of inertia about it is I. A weight mg is attached to the end of the cord and falls from rest. After falling through a distance h, the angular velocity of the wheel will be.

A. $\sqrt{\dfrac{2gh}{I+mr}}$

B. $\left[\dfrac{2mgh}{I+mr^2}\right]^{1/2}$

C. $\left[\dfrac{2mgh}{I+2mr^2}\right]^{1/2}$

D. $\sqrt{2gh}$

Answer: B

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Exercise 2 Concept Applicator

1. Consider a two particle system with particles having masses m_1 and m_2 if the first particle is pushed towards the centre of mass through a distance d, by what distance should the second particle is moved, so as to keep the center of mass at the same position?

A. $\frac{m_2}{m_1}d$

B. $\frac{m_1}{m_1+m_2}d$

C. $\frac{m_1}{m_2}d$

D. d

Answer: C

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2. A ring of mass M and radius R is rotating about its axis with angular velocity ω. Two identical bodies each of mass m are now

gently attached at the two ends of a diameter of the ring. Because of this, the kinetic energy loss will be :

A. $\frac{m(M+2m)}{M}\omega^2 R^2$

B. $\frac{Mm}{(M+m)}\omega^2 R^2$

C. $\frac{Mm}{(M+2m)}\omega^2 R^2$

D. $\frac{(M+m)M}{(M+2m)}\omega^2 R^2$

Answer: C

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3. A weightless ladder 20 ft long rests against a frictionless wall at an angle of 60° from the horizontal. A 150 pound man is 4 ft from the top of the ladder. A horizontal force is needed to keep it from slipping. Choose the correct magnitude from the following.

A. 175 1b

B. 100 1b

C. 120 1b

D. 17.3 1b

Answer: D

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4. A thick walled hollow sphere has outer radius R. It rolls down an inclined plane without slipping and its -speed at the bottom is v. If the inclined plane is frictionless and the sphere slides down without rolling, its speed at the bottom $5v/4$. What is the radius of gyration of the sphere?

A. $3R_0/2$

B. $3R_0/4$

C. $9R_0/16$

D. $3R_0$

Answer: B

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5. A child is standing with folded hands at the center of a platform rotating about its central axis. The kinetic energy of the system is K. The

child now stretches his arms so that the moment of inertia of the system doubles. The kinetic energy of the system now is

A. 2K

B. $\frac{K}{2}$

C. $\frac{K}{4}$

D. 4K

Answer: B

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6. A uniform thin rod AB of length L has linear mass density $\mu(x) = a + \frac{bx}{L}$, where x is measured from A. If the CM of the rod lies at a distance of $\left(\frac{7}{12}L\right)$ from A, then a and b are related as :_

A. $a = 2b$

B. $2a = b$

C. $a = b$

D. $3a = 2b$

Answer: B

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7. Acertain bicycle can go up a gentle incline with constant speed when the frictional force of ground pushing the rear wheel is $F_2 = 4N$. With what force F_1 must the chain pull on the sprocket wheel if $R_1 = 5cm$ and $R_2 = 30cm$?

A. 4N

B. 24N

C. 140N

D. $\frac{35}{4}N$

Answer: B

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8. A particle of mass m is projected with a velocity v making an angle of 45° with the horizontal. The magnitude of the angular momentum of the projectile abut the point of

projection when the particle is at its maximum height h is.

A. $m\sqrt{2gh^3}$

B. $\frac{mv^3}{\sqrt{2g}}$

C. $\frac{mv^3}{4\sqrt{2g}}$

D. zero

Answer: C

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9. A thin bar of length L has a mass per unit length λ, that increases linerarly with distance from one end. If its total mass is M and its mass per unit length at the lighter end is λ_0, then the distance of the centre of mass from the lighter end is

A. $\frac{L}{2} - \frac{\lambda_\circ L^2}{4M}$

B. $\frac{L}{3} + \frac{\lambda_\circ L^2}{8M}$

C. $\frac{L}{3} + \frac{\lambda_\circ L^2}{4M}$

D. $\frac{2L}{3} - \frac{\lambda_\circ L^2}{6M}$

Answer: C

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10. Two particles A and B of mass m each and moving with velocity v, hit the ends of a rigid bar of the same mass m and length l simultaneously and stick to the bar as shown in the figure. The bar is kept on a smooth horizontal plane. The linear and angular speed of the system (bar + particle) after the

collision are

A. $v_{cm} = 0, \omega = \frac{12}{7}\frac{v}{l}$

B. $v_{cm} = 0, \omega = \frac{4v}{l}$

C. $v_{cm} = 0, \omega = \frac{5v}{l}$

D. $v_{cm} = 0, \omega = \frac{v}{5l}$

Answer: A

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11. Two fly wheels A and B are mounted side by side with frictionless bearings on a common shaft. Their moments of inertia about the shaft are $5.0kgm^2$ and $20.0kgm^2$ respectively. Wheel A is made to rotate at 10 revolution per second. Wheel B, initially stationary, is now coupled to A with the help of a clutch. The rotation speed of the wheels will become

A. $2\sqrt{5}$ rps

B. 0.5 rps

C. 2 rps

D. None of these

Answer: C

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12. 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 a diameter of the ring. The ring now rotates with an angular velocity $\omega' =$

A. $\frac{\omega(m+2M)}{m}$

B. $\frac{\omega(m-2M)}{(m+2M)}$

C. $\frac{\omega m}{(m+M)}$

D. $\frac{\omega m}{(m+2M)}$

Answer: D

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13. A thin rod of length L is lying along the x-axis with its ends at x = 0 and x = L. Its linear density (mass/length) varies with x as $k\left(\frac{x}{L}\right)^n$

where n can be zero or any positive number. If the position X_{CM} of the centre of mass of the rod is plotted against n, which of the following graphs best approximates the dependence of X_{CM} on n?

A. 

B. 

C. 

D. 

Answer: A

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14. A metre stick of length 1m is held vertically with one end in contact of the floor and is then allowed to fall. If the end touching the floor is now allowed to slip, the other end will hit the ground with a velocity of $(g = 9.8m/s^2)$

A. $3.2m/s$

B. $5.4m/s$

C. $7.6m/s$

D. $9.2m/s$

Answer: B

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15. A rectangular piece of dimension $l \times b$ is cut out of central portion of a uniform circular disc of mass m and radius r. The moment of inertia of the remaining piece about an axis

perpendicular to the plane of the disc and passing through its centre is :

A. $m\left[r^2 - \frac{lb}{6\pi r^2}\left(l^2 + b^2\right)\right.$

B. $\frac{m}{2}\left[r^2 - \frac{lb}{6\pi r^2}\left(l^2 + b^2\right)\right]$

C. $\frac{m}{2}\left[r^2 - \frac{\left(l^2 + b^2\right)}{6}\right]$

D. not determinable as mass of the rectangular piece is not given

Answer: B

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16. A pulley is in the form of a disc of mass M and radius R. In following figure two masses M_1 and M_2 are connected by a light inextensible string which passes over the pulley. Assuming that the string does not slip over the pulley, the angular momentum of system at the instant shown, about axis of rotation of pulley is $\left[M_2 + M_1 + \frac{1}{k}M\right]vR$ then find the value of k.

A. 1

B. 2

C. 4

D. 5

Answer: B

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17. From a circular ring of mass M and radius R, an arc corresponding to a 90° sector is removed. The moment of inertia of the

remaining part of the ring about an axis passing through the centre of the ring and perpendicular to the plane of the ring is k times MR^2. Then the value of k is

A. $3/4$

B. $7/8$

C. $1/4$

D. 1

Answer: A

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18. Fig shows three particles A, B and C on the x-axis. They are given velocities of $v_1 = 3m/s, v_2 = 2m/s$ and $v_3 = 5m/s$ respectively in the directions shown.

The position of centre of mass A, B and C at time t = 1 s will be

A. $x = 11\frac{2}{3}m$

B. $x = 15\frac{1}{3}m$

C. $x = 10\frac{1}{3}m$

D. $x = 10\frac{2}{3}m$

Answer: C

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19. A hollow sphere of mass 2 kg is kept on a rough horizontal surface. A force on 10 N is applied at the centre of the sphere as shown in the figure.

The minimum value of μ so that the sphere

starts pure rolling is $\left(g = 10m / s^2\right)$

A. $\sqrt{3} \times 0.16$

B. $\sqrt{3} \times 0.08$

C. $\sqrt{3} \times 0.1$

D. None of these

Answer: B

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20. Moment of inertia of a uniform-disc of mass m about an axis $x = a$ is mk^2, where k is the radius of gyration. What is its moment of inertia about an axis $x = a + b$:

A. $mk^2 + m(a+b)^2 - ma^2$

B. $mk^2 + m\frac{(a+b)^2}{2}$

C. $mk^2 + m\frac{b^2}{2}$

D. $mk^2 + mb^2$

Answer: A

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21. A circular disc of radius R is removed from a bigger circular disc of radius 2R such that the cirucmferences of the discs coincide. The centre of mass of the new disc is $\frac{\alpha}{R}$ from the center of the bigger disc. The value of α is

A. $1/4$

B. $1/3$

C. $1/2$

D. $1/6$

Answer: B

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22. Moment of inertia of an equilateral triangular lamina ABC, about the axis passing through its centre O and perpendicular to its plane is $I_{\circ}$ as shown in the figure. A cavity DEF is cut out from the lamina, where D, E, F are the mid points of the sides. Moment of inertia of the remaining part of lamina about the

same axis is :

A. $\frac{7}{8}I_{\circ}$

B. $\frac{15}{16}I_{\circ}$

C. $\frac{3I_{\circ}}{4}$

D. $\frac{31I_{\circ}}{32}$

Answer: B

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23. A thin uniform rod of length l and mass m is swinging freely about a horizontal axis passing through its end. Its maximum angular speed is ω. Its centre of mass rises to a maximum height of -

A. $\frac{1}{6}\frac{l\omega}{g}$

B. $\frac{1}{2}\frac{l^2\omega^2}{g}$

C. $\frac{1}{6}\frac{l^2\omega^2}{g}$

D. $\frac{1}{3}\frac{l^2\omega^2}{g}$

Answer: C

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24. A large disc has mass 2kg and radius 0.2 m and initial angular velocity 50 rad/s and small disc has mass 4kg and radius 0.1 m and initial angular velocity 200 rad/s both rotating about their common axis. Then the common final angular velocity after discs are in contact is,

A. 40

B. 60

C. 100

D. 120

Answer: C

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25. The spool shown in figure is placed on a rough surface has inner radius r and outer radius R. The angle θ between the applied force and the horizontal can be varied. The critical angle (θ) for which the spool does not

roll and remains stationary is given by

A. $\sin\theta = \frac{r}{R}$

B. $\cos\theta = \frac{r}{R}$

C. $\cos\theta = \sqrt{\frac{r}{R}}$

D. $\cos\theta = \frac{2r}{R}$

Answer: B

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26. Two masses m_1 and m_2 are connected by a massless spring of spring constant k and unstretched length l. The masses are placed on a frictionless straight channel, which are consider our x-axis. They are initially at $x = 0$ and $x = l$ respectively. At t = 0, a velocity v_0 is suddenly imparted to the first particle. At a later time t, the centre of mass of the two masses is at :

A. $x = \dfrac{m_2 l}{m_1 + m_2}$

B. $x = \frac{m_1 l}{m_1 + m_2} + \frac{m_2 v_0 t}{m_1 + m_2}$

C. $x = \frac{m_2 l}{m_1 + m_1} + \frac{m_2 \_ v_0 t}{m_1 + m_2}$

D. $x = \frac{m_2 l}{m_1 + m_2} + \frac{m_1 v_0 t}{m_1 + m_2}$

Answer: D

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27. Cement, sand and seree are dropped in rotating cylidrical drum to make concrete mixture. If rotating speed of drum is very high then contents are attached to wall of drum

and mixture is not formed correctly. If radius of drum is 1.25 m and its axis is horizontal, then the required maximum rotating speed to make good mixture in rpm is -

A. 27.0

B. 0.4

C. 1.3

D. 8.0

Answer: A

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28. A tennis ball (treated as hollow spherical shell) starting from O rolls down a hill. At point A the ball becomes air borne leaving at an angle of 30° with the horizontal. The ball strickes the ground at B. What is the value of the distance AB?

(Moment of inertia of a spherical shell of mass m and radius R about its diameter = $\frac{2}{3}mR^2$)

A. $1.87m$

B. $2.08m$

C. $1.57m$

D. $1.77m$

Answer: B

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