PHYSICS

BOOKS - CHHAYA PHYSICS (BENGALI ENGLISH)

CIRCULAR MOTION

Numerical Examples

1. Determine the angular velocities of the second, minute and hour hands of a clock.

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2. A car is moving along a circular path of radius 20 m with a speed of 40 km $\cdot h^{-1}$. Find its angular velocity.

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3. Calculate the angular velocity of earth about its own axis.

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4. Find the time interval between two successive overlaps of the hour hand and the minute hand of a clock.

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5. An electric fan is revolving with a velocity of 210 rpm. When its motion is increased with the help of a regulator, it attains a velocity of 630 rpm in 11 s. What is the angular acceleration of the fan? Also calculate the

number of revolutions completed by the fan in that 11 s ?

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6. A wheel rolls on a horizontal path with uniform velocity. Prove that the velocity of any point on the circumference of the wheel with respect to its centre is equal to the velocity of the wheel. What will be the instantaneous velocity of the point on the wheel which touches the ground?

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7. Starting from rest, a wheel, with uniform acceleration, attains an angular velocity of 60 rad $\cdot s^{-1}$ at the end of 30 complete revolutions. What is the angular acceleration of the wheel?

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8. A cyclist speeding at 18 km/h on a level rod takes a sharp circular turn of radius 3 m

without reducing the speed and without spending towards the centre of the circular path. The coefficient of static friction between the tyres and the road is 0.1. Will the cyclist slip while taking the turn?

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9. A cyclist is moving in a circular path of radius 20 m with a velocity of 18 km $\cdot h^{-1}$, what is his inclination with the vertical?

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10. A mass is suspended from the ceiling by a string revolving in a horizontal circle of radius 5 cm. The tangential speed of the mass is 0.7 $m \cdot s^{-1}$. What is the angle between the string and the vertical? (Consider acceleration due to gravity as 9.8 $m \cdot s^{-2}$)

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11. A coin is placed on a horizontal turntable rotating at $33\frac{1}{3}$ rpm. The coin revolves with the table without slipping provided the coin is not more that 10 cm away from the axis. How far from the axis can the coin be placed so that it revolves with the table without slipping if the turntable rotates at 45 rpm ?

(g = 980 cm $\cdot$ s^{-2})

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12. A small body is kept at a distance of 7 cm from the centre of a gramophone disc. The disc starts rotating with gradually increasing speed and the body is just on the verge of being thrown off when the disc rotates at 60 rpm. What will be the rate of rotation of the disc when the body, kept at a distance of 12 cm from the centre, is just being thrown off?

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13. The driver of a truck travelling with a velocity v suddenly notices a wall in front of him at a distance d. Is it better for him to apply brakes or to make a circular turn without applying brakes in order to just avoid crashing into the wall?

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14. A body is kept at rest at a distance of 10 cm from the centre of a gramophone disc. If the

coefficient of friction between the body and the disc is 0.3, then for what maximum rps of the disc, will the body not be thrown off the disc?

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15. The radius of curvature of a railway track at a bend is 500 m. The distance between the two tracks is 1 m and the outer line is 4 cm higher than the inner. At what maximum speed can a train bend round the curve

without exerting lateral pressure on the outer line?

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16. A tube of length L is filled completely with an incompressible liquid of mass M and its two open ends are closed. The tube is then rotated with an angular velocity ω with one end of its as the centre. What will be the force exerted by the liquid on the other end?

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17. A hemispherical bowl of radius 0.1m is rotated about a vertical axis passing through the centre of the bowl with an angular velocity ω. A particle of mass m = 10^{-2} kg placed inside the bowl also the particle from the bottom of the bowl is h, find the relation between h and ω.

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18. The radius of the earth is 6400 km. What will be the value of the centrifugal acceleration at the equatorial region due to the earth's diurnal motion?

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19. A round table is rotated with an angular velocity of 10 rad $\cdot s^{-1}$ about its axis. Two blocks of mass $m_1 = 10\text{kg}$ and $m_2 = 5$ kg , connected to each other by a weightless

inextensible string of length 0.3 m, are placed along a diameter of the table. the coefficient of friction between the table and m_1 is 0.5, while there is no frication between m_2 and the table. Mass m_1 is at a distance of 0.124 m from the centre of the table. The masses are at rest with respect to the table. (i) Calculate the frictional force on m_1. (ii) What should be the minimum angular speed of the table so that masses will slip from the table? (iii) how should these masses be kept so that the string remains taut but no frictional force acts on m_1 ?

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20. What should be the maximum speed of a motor car of mass 2000 kg when it takes a circular turn of redius 100 m on a plane road? Coefficient of friction between the tyre and the road = 0.25 . Given,

g = 10 m $\cdot$ s^{-2}.

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21. The roadway bridge over a stream is in the form of an are of a circle of radius r. A car is crossing the bridge with a speed v. Prove that the limiting speed of the car with which it can cross the bridge without leaving the ground at the highest point of the bridge is v $\leq \sqrt{gr}$.

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22. What will be the angular velocity of the diurnal motion of the earth, so that the

weight of a body at the equatorial region is 0.6 of the present weight? Radius of the earth = 6400 km.

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23. A cylindrical drum made of steel and of diameter 20 cm is rotating about its own vertical axis. A small body made of steel remains stuck inside the cylinder when the drum rotates at the rate of 200 rpm. When the velocity of rotation decreases, the body falls

down. What is the coefficient of friction between the body and the surface of the drum?

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24. Four balls of mass 5 kg each are placed on the top of a horizontal turntable and fastened together with four strings of length 1 m each to from a square of side 1m. The axis of rotation passes through the centre of the

square. Find the tension in the strings when the turntable is rotated at the rate of $\frac{30}{\pi}$ rpm.

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25. A hemispherical bowl of radius r is rotated with an angular velocity ω about a vertical axis passing through its centre. An object with the same angular velocity remaining attached with the inner surface of the bowl. The straight line joining the body and the centre of the bowl makes an angle 45° with the vertical. The

coefficient of friction between the body and the bowl is 0.2, Assuming the body is just about to move down along curved surface of the bowl, prove that $\omega^2 r = 0.943\ \text{g}$.

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26. A car of mass m is moving with a velocity v over a bridge. What will be the values of the force F at the highest point of a convex bridge and at the lowest point of a concave bridge?

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27. The roadway bridge over a stream is in the form of an arc of a circle of radius 50 m. What is the maximum speed with which a car can cross the bridge without leaving the ground at the highest point?

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28. A car passes over a convex bridge. The centre of gravity of the car follows an arc of a circle of radius 30 m. Assuming that the car

has a mass of 1000 kg, find the force that the car will exert at the highest point on the bridge, if the velocity of the car is 15 $m \cdot s^{-1}$. At what speed will the car lose contact with the road?

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29. A spotlight is rotating with a uniform angular velocity of 0.1 $rad \cdot s^{-1}$ on a horizontal plane. The light-spot moves on a wall at a distance of 3m. If the path of light

inclines at an angle of 45° with the wall, then calculate the velocity of the light-spot.

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30. A piece of mass 1 kg is tied with a thread of length 10 m and is rotating along a horizontal circular path making an angle θ with the vertical. The thread can withstand a maximum tension of 12 N. What is the maximum velocity

with which the stone can be rotated without snapping the thread?

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Section Related Questions

1. Like linear velocity, is angular velocity a vector quantity? If so, then how can we determine its directon?

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2. Establish the relation between angular velocity and frequency.

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3. Establish the relation between linear velocity and angular velocity.

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4. What is the unit of angular velocity?

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5. Define angular acceleration. What is its unit?

Watch Video Solution

6. Establish the relation between linear acceleration and angular acceleration.

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7. If the equation of linear uniform motion is s = vt, write the analogous equation for uniform circular motion.

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8. What do you mean by centripetal acceleraton?

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9. What do you mean by centripetal force?

Watch Video Solution

10. Centripetal force does no work' - explain.

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11. What are the centripetal forces in the following examples?

Revolution of the earth around the sun.

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12. What are the centripetal forces in the following examples?

Turning of a car on a horizontal circular road.

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13. What are the centripetal forces in the following examples?

Horizontal circular motion of a stone tied with a string.

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14. Define centrifugal force.

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15. What is a pseudo force? In which reference frame does it exist?

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Higher Order Thinking Skill Hots Questions

1. Why is a centripetal force necessary for a uniform circular motion ?

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2. Centripetal force is called a real force, but centrifugal force is called a pseudo force. Give reasons in support of this statement.

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3. What should be the length of a day on the earth when a body has no apparent weight at the equatorial region? (Radius of the earth = 6400 kg) or, should be the time period of rotation of the earth about its own axis so that a person on the equator feels weightless? (Equatorial radius = 6400 km, g = 9.8 m $\cdot$ s^{-2})

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4. What is the maximum speed with which a car can move over a convex bridge?

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5. Radius of corved path is r and the coefficient of friction between the wheel of a car and that path is μ. What should be the maximum speed with which the car can take a turn without skidding in that curved path?

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6. While taking a turn, is it possible for a cyclist to lean at an angle of 45° with the vertical?

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7. A stone is tied to the end of a string. When the string is whirled in a circular path, the string can never be kept horizontal. Explain the reason.

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8. When a body is hung from a string. It does not snap. But when the same mass is set into rotation along a horizontal path at high speed holding the other end of the string. The string snaps. What is the reason?

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9. Two indentical trains are running in opposite directions over two tracks along the

equator with equal speed. Will both the trains exert the same force on the tracks?

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10. A hollow cylinder of radius r is rotating about its own vertical axis. Both ends of the cylinder are open. A piece of stone of mass m remains fixed on the inner side of the cylinder. What should be the minimum velocity of rotation of the cylinder so that the stone remains fixed on the surface of the cylinder

without falling down? Coefficient of static friction between the wall of the cylinder and the stone = μ, acceleration due to gravity = g. Also, prove that this velocity is independent of the mass of the stone.

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11. When a moving bus takes a right turn, the passengers inside the bus seem to lean towards the left. Explain why.

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12. A small glass marble is put on a smooth gramophone disc. When the disc starts rotating, the marble flies off the disc. Explain why.

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13. In a circus show, a motorcycle rider inside a ' deathwell' can revolve on the erect wall without falling down. What is the reason behind it?

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14. Why should a signboard mentioning the safe maximum speed the sited before the bend on a horizontal road or railway tracks?

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15. When a motor car travels on a convex road the passengers inside feel lighter. Why?

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16. A funnel is rotating around its vertical axis with a constant frequency ν rev/s. A small cube of mass m is placed on the inside wall of the funnel carefully. The wall of the funnely makes an angle θ with the horizontal. If μ is the coefficient of friction between the funnel and the cube, r is the distance between the centre of mass of the cube and the rotational axis, then find the maximum and minimum value of ν for which the cube remains static

with respect to the funnel.

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17. Why are the bends of a road or of a railway track banked?

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18. Why do we feel lighter and heavier at the highest and lowest points of a Ferris wheel?

Suppose, the Ferris wheel is revolving with a constant angular velocity.

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Exercise Multiple Choice Questions

1. A wheel is rotating 300 times per minute. The angular velocity of the wheel in rad $\cdot s^{-1}$ unit is

A. 10π

B. 20π

C. 30π

D. 5π

Answer: A

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2. Two bodies of masses m_1 and m_2 are moving at uniform speed along circular paths of radii r_1 and r_2 respectively. If they take

equal time to describe the cricles completely, the ratio of their angular velocities will be

A. $\frac{r_1}{r_2}$

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

C. $\frac{m_1 r_1}{m_2 r_2}$

D. 1

Answer: D

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3. If a body travels along a circular path with uniform speed then its acceleration

A. acts along its circumference

B. acts along its tangent

C. acts along its radius

D. is zero

Answer: C

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4. After switching on a ceiling fan it completes 10 revolutions in 3 s. The number of complete revolutions it will perform in the next 3 s (assuming uniform angular acceleration) is

A. 10

B. 20

C. 30

D. 40

Answer: C

5. If wheel revolves 120 times per minute then its angular velocity in rad $\cdot s^{-1}$ unit is

A. π^2

B. 4π

C. 2π

D. $4\pi^2$

Answer: B

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6. Angular velocity of the hour hand of a clock is

A. $\frac{\pi}{30}\ \text{rad} \cdot s^{-1}$

B. $2\pi\ \text{rad} \cdot s^{-1}$

C. $\frac{\pi}{1800}\text{rad} \cdot s^{-1}$

D. $\frac{\pi}{21600}\text{rad} \cdot s^{-1}$

Answer: D

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7. If a particle rotates along a circular path of radius 25 cm with a frequency of 2 rps, its linear acceleration in $m \cdot s^{-2}$ unit is

A. π^2

B. $2\pi^2$

C. $4\pi^2$

D. $8\pi^2$

Answer: C

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8. An artificial satellite takes 90 minutes to complete its revolution around the earth. The angular speed of the satellite is

A. $\frac{\pi}{1800}\text{rad} \cdot s^{-1}$

B. $\frac{\pi}{2700}\text{rad} \cdot s^{-1}$

C. $\frac{2\pi}{2700}\text{rad} \cdot s^{-1}$

D. $\frac{\pi}{45}\text{rad} \cdot s^{-1}$

Answer: B

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9. The driver of a truck suddenly finds a wall in front of him. To avoid collision with the wall he should

A. apply brake at once

B. turn speedily in a circular path

C. follow both the processes (a) and (b)

D. do none of the above processes

Answer: A

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10. Which of the following quantities does not remain constant in a uniform circular motion?

A. speed

B. momentum

C. kinetic energy

D. mass

Answer: B

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11. The angular velocity of a particle, $\overrightarrow{w} = 3\hat{i} - 4\hat{j} + \hat{k}$ and its position vector, $\overrightarrow{r} = 5\hat{i} - 6\hat{j} + 6\hat{k}$. What is the linear velocity of the particle?

A. $-18\hat{i} + 13\hat{j} + 2\hat{k}$

B. $18\hat{i} - 13\hat{j} - 2\hat{k}$

C. $-18\hat{i} - 13\hat{j} + 2\hat{k}$

D. $18\hat{i} + 13\hat{j} - 2\hat{k}$

Answer: C

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12. The ratio of angular speeds of minute hand and hour hand of a watch is

A. $1:12$

B. $6:1$

C. $12:1$

D. $1:6$

Answer: C

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13. A particle of moves with constant angular velocity in a circle. During the motion its

A. energy is conserved

B. momentum is conserved

C. energy and momentum both are conserved

D. none of the above

Answer: A

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14. The angular speed of a flywheel making 360 revolutions per minute is

A. $12\pi \ \ \mathrm{rad} \cdot s^{-1}$

B. $6\pi \ \ \mathrm{rad} \cdot s^{-1}$

C. $3\pi \ \ \mathrm{rad} \cdot s^{-1}$

D. $2\pi \ \ \mathrm{rad} \cdot s^{-1}$

Answer: A

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15. A car moves on a circular road. It describes equal angles about the centre in equal intervals of time. Which of the following statements about the velocity of the car is true?

A. magnitude of velocity is not constant

B. both magnitude and direction of velocity change

C. velocity is directed towards the centre of the circle

D. magnitude of velocity is constant but direction changes

Answer: D

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16. A wheel of radius R rolls on the ground with a uniform velocity v. the velocity of topmost point relative to the bottommost point is

A. v

B. 2 v

C. $\frac{v}{2}$

D. zero

Answer: B

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17. The angle with which a cyclist leans with the horizontal while turning a curved path of radius r with speed v is

A. $\theta = \tan^{-1} \quad \frac{v^2}{rg}$

B. $\theta = \tan^{-1} \quad \frac{rg}{v^2}$

C. $\theta = \tan^{-1} \quad v^2 rg$

D. $\theta = \tan^{-1} \quad \frac{r}{rg}$

Answer: B

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18. While taking a turn on a plane horizontal road, a car can skid due to

A. gravitational force

B. absence of necessary centripetal force

C. rolling friction between the tyre of the car and the road

D. reaction force of the road

Answer: B

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19. A car is moving along a horizontal circular path of radius 10 m at a uniform speed of 10 m $\cdot s^{-1}$. A pendulum bob is suspended by means of a light rod from the ceiling of the car. The angle made by the rod with the horizontal path will be (g = 10$m \cdot s^{-2}$)

A. zero

B. 30°

C. 45°

D. 60°

Answer: C

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20. If maximum and minimum tension in the string whirling in a circle of radius 2.5 m are in the ratio 5 : 3 then its velocity is

A. $\sqrt{98}m \cdot s^{-1}$

B. $\sqrt{7}m \cdot s^{-1}$

C. $\sqrt{490}m \cdot s^{-1}$

D. $\sqrt{4.9}m \cdot s^{-1}$

Answer: A

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21. Coefficient of friction between the road and the tyre of a car is 0.6. What is the maximum safe limiting speed with which the car can overcome a bend of radius 150 m ?

A. $60 \quad m \cdot s^{-1}$

B. $15 \quad m \cdot s^{-1}$

C. $30 \quad m \cdot s^{-1}$

D. $25 \quad m \cdot s^{-1}$

Answer: C

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22. A body is moving in a circular path with centripetal acceleration a . It its speed gets doubled, find the ratio of the centripetal acceleration after and before the speed in changed.

A. $1:4$

B. $1:2$

C. $2:1$

D. $4:1$

Answer: D

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23. A ball of mass 0.12kg is being whirled in a horizontal circle at the end of string 0.5 m long. It is capable of making 231 revolutions in

one minute. The breaking tension of the string is

A. 3N

B. 15.1 N

C. 31.5 N

D. 35.1 N

Answer: D

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24. A car is moving in a circular horizontal track of radius 10 m with a constant speed of 10 m $\cdot s^{-1}$. A plumb bob is suspended from the roof of the car by a light rigid rod of length 1.0 m . The angle made by the rod with the track is (g = 10 m $\cdot s^{-2}$)

A. zero

B. 30°

C. 45°

D. 60°

Answer: C

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25. The motor of an engine is rotating about its axis with an angular velocity of 100 rpm. It comes to rest in 15 s, after being switched off. Assuming constant angular deceleration, what are the numbers of revolutions made by it before coming to rest ?

A. 12.5

B. 40

C. 32.5

D. 15.6

Answer: A

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Very Short Answer Type Questions

1. Name the unit of angular displacement.

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2. State true or false-an angle measured in radian is dimensionless.

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3. What kind of vector is angular velocity?

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4. What is the angular velocity of the second hand of a clock?

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5. Uniform circular motion is an example of uniform velocity'-state whether the statement is correct.

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6. What do you mean by the term frequency?

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7. What is the relation between time period and frequency?

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8. What is the dimension of angular acceleration?

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9. 1 rps = _____ rpm = _____ rph.

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10. 1 rpm = ? Rad $\cdot s^{-1}$

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11. What is the vector relation of linear acceleration $\vec{a}$ and angular acceleration $\left(\vec{\alpha}\right)$?

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12. In the case of uniform circular motion, the velocity and the acceleration are perpendicular to each other.

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13. What is the angular velocity of the minute hand of a clock in rad $\cdot s^{-1}$?

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14. If the frequency of revolution of a body is n, then what will be the velocity of revolution?

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15. A particle of mass m is moving in a circular path of radius r with a uniform speed v. The centripetal force on the body is $\frac{m\omega^2}{r}$. When the particle is displace half of the distance, then what is the work done by the centripetal force?

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16. What does supply the necessary centripetal force when a stone tied with a string is

rotated along a circular path?

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17. What does provide a planet the necessary centripetal force to revolve around the sun?

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18. If a particle moves in a circular path with constant speed, what should be the direction of its resultant acceleration?

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19. In the case of railway tracks, which rail is to be kept at a slightly higher level near a bend?

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20. The radius of a curved path is r and the coefficient of friction between a car and the path is μ. What is the maximum speed at

which the car can turn at a bend without skidding?

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21. Is it possible for a cyclist to lean through an angle of 45° with the vertical when he takes a turn?

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22. Why is centripetal force so called?

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23. For uniform circular motion, does the direction of the centripetal force depend on the sense of rotation (i.e., clock-wise or anti-clock wise)?

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24. A body is moving along a circular path such that its speed always remains constant.

Should there be a force acting on the body?

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25. What type of acceleration does a body moving along a circular path possess?

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26. A piece of stone is tied with a thread and is rotated along a horizontal circular path. If the

thread snaps? Suddenly, in which direction will the stone fly?

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27. What supplies the necessary centripetal force to the electrons in an atom to revolve around the nucleus?

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28. When a car turns towards right while moving, the passengers inside the car lean towards____.

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29. To avoid accident of a moving car near a bend,___ force is supplied by banking the road.

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30. A cyclist is riding on a cycle with speed v and while negotiating a circular path of radius r, he leans at an angle θ with the ground. Then, what will be the value of $\tan\theta$?

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31. Angular momentum of a body of mass m rotating along a circular path of radius r with uniform speed is L. What is the magnitude of the centripetal force acting on it?

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32. When a motor car moves speedily on a convex path, how do the passengers inside the car feel?

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33. At which plane on earth, the centripetal force is maximum?

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34. Due to which type of force butter comes out during stirring of milk?

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35. A body of mass m is rotated along a circular path of radius r with uniform speed v. Centripetal force acting on the body is $\frac{mv^2}{r}$. If the body travels through a semicircular path, then what will be the work done by the centripetal force?

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Short Answer Type Question I

1. Is circular motion possible at constant speed? Explain.

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2. What does provide the centripetal force to a car taking a turn on a level road?

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Short Answer Type Questions Ii

1. A particle is rotating along a circular path at uniform speed. Indicate the direction of displacement, velocity and acceleration of the particle at any moment with the help of a diagram.

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2. Is the angular velocity of rotation of hour hand of a watch greater or smaller than the angular velocity of earth's rotation about its axis? Explain.

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Problem Set I

1. A car is moving with a velocity of 36 km $\cdot h^{-1}$. If the diameter of its wheel is 0.7 m,

what will be its angular velocity?

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2. An electric fan acquires frequency of 300 rpm after completing 5 revolutions when it is switched on. Determine the angular acceleration of the fan and the time taken to acquire the frequency of 300 rpm.

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3. Velocity of a car along a curved path of radius of curvature 100 m is 36 km $\cdot h^{-1}$. What is the angular velocity of the car?

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4. The length of the second hand of a clock is 21 cm. What will be the magnitude of linear velocity of its extreme point?

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5. A car can move at a maximum speed of 72 km $\cdot h^{-1}$ on a curved road of radius of curvature 100 m. what is the coefficient of friction between the tyres of the car and the road?

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6. A flywheel makes 120 rpm. Find the angular speed of any point on the wheel and the linear speed of a point 10 cm from the centre of the wheel.

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7. A cyclist is going round a circular track with a speed of 10 m $\cdot s^{-1}$. If the radius of the track is 80 m, calculate the angular speed of the cyclist.

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8. While taking a turn on a circular road with a velocity of 36 km $\cdot h^{-1}$, a cyclist leans at an

angle of 30° with the vertical. What is the radius of the circular road?

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9. A motorcycle rider, in the 'death-well' show in a circus, is revolving along a circular path of radius r on the wall of the well. If the coefficient of friction between the wall and the tyres of the motorcycle is μ, then what minimum velocity should be maintained by the rider?

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10. A body of mass 0.1 kg is being rotated in a circular path of diameter 1.0 m on a frictionless horizontal plane by means of a string. It performs 10 revolutions in 31.4s. Calculate the centripetal force acting on the body.

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11. A motor car of mass 1000 kg runs over a bridge at 48 km/hr the roadway in the form of an arc of radius 20 m. Find the reaction between the car and the road at the lowest point of the car.

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12. Two bodies of masses 10 kg and 5 kg are revolving along two concentric circular path of radii R and r , respectively, in such a manner

that the time periods of revolution for both of them are equal. Determine the ratio of the centripetal acceleration of the two bodies.

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13. A particle revolves in a circle of radius 0.1 m, making 300 rpm. Calculate its linear velocity and centripetal acceleration.

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14. A table is rotating along a horizontal plane about the axis passing through its centre. A thread is passed through a hole made at the centre of the table and two bodies of equal mass are tied at a distance of 20 cm thread. The body on the table is at a distance of 20 cm from the centre of the table. For what rpm of the table. will the hanging body be at rest?

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15. Two bodies of masses 1 kg 3 kg are tied at the two ends of a thread 60 cm and the arrangement is kept diametrically on a table. If the table is rotated about an axis passing through its centre, then it is observed that no motion in the thread is generated along the diameter. What is the distance of the 1 kg mass from the centre of the table?

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16. In a machine, a horizontal arm of 2 m is connected with a vertical shaft and is rotated at an angular velocity of 600 rpm in a horizontal plane. A 10 kg block is attached to the free end of the arm. Find out the force on the block and the force on the vertical shaft due to rotation of the block.

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17. A road curve is banked so that there is no side thrust on the passengers in a car which negotiate the curve at 72 km/hr speed . Find the angle of banking for a circular curve making a 90° turn in a distance of 157 m along the road.

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Problem Set Ii

1. The wheel of a car of radius 0.7 m is moving with an angular velocity of $10\pi \ \ \mathrm{rad} \cdot s^{-1}$. If the car is to be brought to rest by applying brakes within $\frac{1}{2}$ s, what will be the distance covered by the car during that time?

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2. An electric fan of radius 1.2 m is rotating with a steady frequency of 300 rpm. Determine

the angular velocity of the fan and also find out the linear velocity of any end-point.

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3. The engine of a motor car is rotating at a constant speed of 150 rpm. Acquiring acceleration suddenly it gains a velocity of 3000 rpm in 3 s.

What is the angular acceleration of the engine?

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4. The engine of a motor car is rotating at a constant speed of 150 rpm. Acquiring acceleration suddenly it gains a velocity of 3000 rpm in 3 s.

what will be its angular velocity after 2 s ?

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5. The engine of a motor car is rotating at a constant speed of 150 rpm. Acquiring acceleration suddenly it gains a velocity of

3000 rpm in 3 s.

What will be the angular displacement of it in 3 s?

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6. A wheel completes 400 revolutions in 1 minute. Its speed is increased to 600 rpm in 4 s. Determine

the angular acceleration .

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7. A wheel completes 400 revolutions in 1 minute. Its speed is increased to 600 rpm in 4 s. Determine

The number of revolutions completed by the wheel in that time.

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8. Find the acceleration of a particle placed on the surface of the earth at the equator due to earth's rotation. The diameter of earth = 12800

km and it takes 24 hours for the earth to complete one revolution about its axis.

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9. A park has a radius of 10 m. If a vehicle goes round it at an average speed of 18 km/hr, what should be the proper angle of banking?

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10. What is the percentage decrease in the weight of a body at the equatorial region of the earth due to its diurnal motion? Given, radius of the earth = 6400 km, $\pi^2 = 9.8$

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11. A circular disc rotates at 60 rpm about an axis passing through its centre. A coin of 18 g is placed at a distance of 8 cm from the centre

of the disc. Calculate the centrifugal force on the coin.

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12. A piece of stone of mass 2 kg is tied with a thread of length 5 m and is rotated along a horizontal circular path. The thread can withstand a maximum tension of 30 N. What is the maximum velocity with which the stone can be rotated without snapping the thread?

Also find the maximum number of revolutions that the stone can complete in one minute.

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13. A hollow cylinder of diameter 20 cm is rotating about its own vertical axis. If the angular velocity of the cylinder is not less than 180 rpm, then a body remains attached on the inside wall of the cylinder and keeps rotating with the cylinder. What is the coefficient of rotating with the cylinder. what is the

coefficient of friction between the body and the wall of the cylinder? Given, $\pi^2 = 9.8$.

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14. A ball of mass 100 g is suspended by a string of 40 cm long. Keeping the string always taut, the ball describes a horizontal circle of radius 10 cm. Find the angular speed of the ball.

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15. A body of 500 g is tied to one end of a string 2 m long and is revolved in a horizontal circle. If the string breaks under a load of 4.84 kgf, find the maximum number of revolutions per minute the body can make without breaking the string. (g = 9.8 m $\cdot$ s^{-2})

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16. Velocity of a car along a path of radius of curvature 100 m is 36 km $\cdot$ h^{-1}.

Determine its normal acceleration.

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17. Velocity of a car along a path of radius of curvature 100 m is 36 km $\cdot h^{-1}$.

If the mass of the car is 500 kg, find the magnitude and direction of the statric friction.

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18. A stone is kept hanging from the end of a round table of radius 22.6 cm by means of a

thread. The table is rotated such that the thread makes an angle of 30° with the vertical. What is the angular velocity of the table?

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19. A circular race track of radiu 400 m is banked at an angle of 10°. If the coefficient of friction between the wheels of a race car and the road is 0.2, what is the

(i) optimum speed of the race car to avoid

wear and tear on its tyres?

maximum permissible speed to avoid slipping?

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20. A car of mass 1500 kg is moving with a speed of 12.5 $m \cdot s^{-1}$ on a circular path of radius 20 m on a level road. What should be the frictional force between the car and the road so that the car does not slip? What should be the value of the coefficient of friction this force?

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Hots Numerical Problems

1. A bridge in the form of an arc should be constructed such that different vehicles can cross the highest point of the bridge at a maximum speed of 180 $km \cdot h^{-1}$ without losing contact with the road. What should be the limiting radius of curvature of the bridge?

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2. A body of mass 4 kg is connected to the two ends of a vertical rod of length 2 m by two threads of length 1.5 m each. The body is rotated about the rod as an axis. To produce a tension of 70 N on the upper string what should be the rpm of the body? What will be the tension in the lower string then?

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3. A mass of 60 g remains attached to the end of a thread of length 4 m. The mass is rotated uniformly in a horizontal circular path. The plane of this circular path is at a vertical distance of 3.2 m from the upper end of the thread. Determine the tension in the thread and the time period of revolution of the mass.

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4. A sphere of mass 200 g remains suspended from a rigid support by means of a thread of length 130 cm. The sphere is rotated in a horizontal circular path of radius 50 cm. Determine its time period of rotation and tension in the thread.

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5. A string of length 1 m is fixed at one end to a rigid support and carries a sphere of 100 g

at the other end. The string makes $\frac{2}{\pi}$ revolutions per second around a vertical axis through the fixed end. Calculate

The angle of inclination of the string with the vertical axis.

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6. A string of length 1 m is fixed at one end to a rigid support and carries a sphere of 100 g at the other end. The string makes $\frac{2}{\pi}$ revolutions per second around a vertical axis

through the fixed end. Calculate

The tension in the string and.

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7. A string of length 1 m is fixed at one end to a rigid support and carries a sphere of 100 g at the other end. The string makes $\frac{2}{\pi}$ revolutions per second around a vertical axis through the fixed end. Calculate

the linear velocity of the sphere.

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8. A particle of mass m is revolving in a circular path of constant radius r such that its centripetal acceleration a_c is verying with time t as $a_c = k^2rt^2$, where k is a constant. Determine the power delivered to the particle by the forces acting on it.

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9. A small body is kept at a distance of 7 cm from the centre of a gramophone disc. The

disc starts rotating with gradually increasing speed and the body is just on the verge of being thrown off when the disc rotates at 60 times a minute. What will be the speed of the disc when the body, kept at a distance of 12 cm from the centre, is just thrown off? What will be the rotational speed, when a body of double the mass is kept at the previous position of 7 cm away from the centre?

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10. A string passes through a hole at the centre of a horizontal table. The upper end of the string is tied to a mass m kept on the table, and at the lower end, a body of mass M is kept hanging. If the table rotates at an angular velocity ω, the mass M remains at rest. Show that, $\omega = \sqrt{\frac{M}{m} \cdot \frac{g}{r}}$.

[r is the radius of the circular path along which the mass m is rotating]

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11. A light mass m and another heavier mass M , are connected by a light inextensible string which passes through a smooth and narrow vertical tube, Keeping the length l of the string inclined at an angle θ with the tube, with what frequency should the mass m be rotated in a horizontal plane so that the mass M will remain in equilibrium?

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12. Two points are taken on a massless wire OC, such that OA = AB = BC. Three bodies of equal mass are tied at the points A, B and C and the system is kept on a horizontal smooth table. Keeping the wire taut, if the system is rotated around the point O, then what will be the ratio of tensions in the three parts of the wire?

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13. A small cube (mass = m) is on the inner curved surface of a funnel rotating about its own axis. Its wall inclines at an angle θ with the horizontal. The cube is kept at a distance r from the vertical axis of rotation of the funnel. If the coefficient of friction between the funnel and the cube is μ, for what frequency of rotation of the funnel, will the cube remain at rest on the surface of the funnel? It is implied that the cube will roll down if the funnel remains stationary.

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14. A carpet of mass M made of inextensible material is rolled along its length in the form of a cylinder of radius R and is kept on a rough floor. The carpet starts unrolling without sliding on the floor when a negligibly small push is given to it. Calculate the horizontal velocity of the axis of the cylindrical part of the carpet when its radius reduces to $\frac{R}{2}$.

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Entrance Corner

1. Statement I: If a car is taking a turn on a banked road, then the normal contact force between car and road is greater than the weight of car (neglecting friction).

Statement II: On a banked road, horizontal component of normal contact force between car and road provides necessary centripetal force. Assume friction is absent.

A. Statement I is true, statement II is true , statement II is a correct explanation for statement I.

B. Statement I is true, statement II is true , statement II is not a correct explanation for statement I.

C. Statement I is true, statement II is false.

D. Statement I is false, statement II is true.

Answer: B

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2. Statement I: A car takes a turn of radius 20 m with constant velocity of 10 m $\cdot s^{-1}$.

Statement II: In circular motion, velocity can never be constant.

A. Statement I is true, statement II is true , statement II is a correct explanation for statement I.

B. Statement I is true, statement II is true , statement II is not a correct explanation

for statement I.

C. Statement I is true, statement II is false.

D. Statement I is false, statement II is true.

Answer: D

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3. Statement I: A particle can perform circular motion without having any tangential component of acceleration.

Statement II: For circular motion to take place, radial acceleration should exist.

A. Statement I is true, statement II is true , statement II is a correct explanation for statement I.

B. Statement I is true, statement II is true , statement II is not a correct explanation for statement I.

C. Statement I is true, statement II is false.

D. Statement I is false, statement II is true.

Answer: B

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4. Statement I: Uniform circular motion is uniformly acceleration motion.

Statement II: Acceleration in uniform circular motion is always towards centre.

A. Statement I is true, statement II is true , statement II is a correct explanation for statement I.

B. Statement I is true, statement II is true , statement II is not a correct explanation for statement I.

C. Statement I is true, statement II is false.

D. Statement I is false, statement II is true.

Answer: D

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5. Statement I: In circular motion average speed and average velocity are never equal.

Statement II: In any curvilinear path these two are never equal.

A. Statement I is true, statement II is true , statement II is a correct explanation for statement I.

B. Statement I is true, statement II is true , statement II is not a correct explanation for statement I.

C. Statement I is true, statement II is false.

D. Statement I is false, statement II is true.

Answer: A

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Multiple Correct Answer Type

1. In uniform circular motion of a particle

A. particle cannot have uniform velocity

B. particle cannot have uniformly acceleration motion

C. particle cannot have net force equal to zero

D. particle cannot have any force in tangential direction

Answer: A::B::C::D

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2. A particle is moving in a circular path with decreasing speed. For this situation, mark out the correct statements.

A. radial component of its acceleration is decreasing in magnitude

B. the angular speed of the particle is decreasing

C. tangential component of its acceleration and velocity are in opposite directions

D. the particle is performing a non-uniform circular motion

Answer: A::B::C::D

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Matrix Match Type

1. In Column I some physical quantities related to translational motion are given, while in

Column II physical quantites associated with rotational motion are mentioned.

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2. A particle is rotating in a circle of radius R = $\frac{2}{\pi}$ m, with constant speed 1 m $\cdot$ s^{-1}. Match the following two columns for the time interval when it completes $\frac{1}{4}$ th of the circle.

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Comprehension Type

1. A particle is moving along a circular path of radius 0.7 m with constant tangential acceleration of 5 $m \cdot s^{-2}$. The particle is initially at rast. Based on the above information, answer the following questions :

The speed of the particle after 7 s is

A. 5 $m \cdot s^{-1}$

B. 7 $m \cdot s^{-1}$

C. 35 $m \cdot s^{-1}$

D. 48 m $\cdot s^{-1}$

Answer: C

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2. A particle is moving along a circular path of radius 0.7 m with constant tangential acceleration of 5 m $\cdot s^{-2}$. The particle is initially at rast. Based on the above information, answer the following questions :

The radial acceleration of the particle at t = 7 s is

A. 1200 m $\cdot s^{-2}$

B. 1750 m $\cdot s^{-2}$

C. 70 m $\cdot s^{-2}$

D. 250 m $\cdot s^{-2}$

Answer: B

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3. A particle is moving along a circular path of radius 0.7 m with constant tangential acceleration of 5 $\mathrm{m} \cdot s^{-2}$. The particle is initially at rast. Based on the above information, answer the following questions :

Distance travelled by the particle in 7 s is

A. 123 m

B. 725 m

C. 728 m

D. 426 m

Answer: A

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4. A particle is moving along a circular path of radius 0.7 m with constant tangential acceleration of 5 $m \cdot s^{-2}$. The particle is initially at rast. Based on the above information, answer the following questions : The number of revolutions made by the particle in 7 s is

A. 27.8

B. 164.8

C. 165.52

D. 96.85

Answer: A

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5. A small particle of mass m attached with a light inextensible thread of length L is moving in a vertical circle. In the given case the

particle is moving in a complete vertical circle and ration of its maximum to minimum velocity is 2 : 1.

Minimum velocity of the particle is

A. $4\sqrt{\frac{gL}{3}}$

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

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

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

Answer: B

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6. A small particle of mass m attached with a light inextensible thread of length L is moving in a vertical circle. In the given case the particle is moving in a complete vertical circle and ration of its maximum to minimum velocity is 2 : 1.

The kinetic energy of the particle at the lowest position is

A. $\frac{4mgL}{3}$

B. 2 mgL

C. $\frac{8mgL}{3}$

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

Answer: C

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7. A small particle of mass m attached with a light inextensible thread of length L is moving in a vertical circle. In the given case the particle is moving in a complete vertical circle and ration of its maximum to minimum

velocity is 2 : 1.

Velocity of the particle when it is moving vertically downward is

A. $\sqrt{\frac{10gL}{3}}$

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

C. $\sqrt{\frac{8gL}{3}}$

D. $\sqrt{\frac{13gL}{3}}$

Answer: A

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Integer Answer Type

1. A particle is moving along a circular path of radius 2 m with constant angular velocity of 3 rad $\cdot s^{-1}$. Detemine the angular displacement (in rad) of the particle in 3 s.

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2. A particle moves in a circle of radius 1.0 cm at a speed given by v = 2.0 t, where v is in cm

$\cdot s^{-1}$ and t in seconds. Find the radial acceleration of the particle at t = 1 s.

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3. If the earth was to suddenly contract to half its present size, without any change in its mass, then what will be the duration of the new days (in hours)?

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Examination Archive With Solutions Wbchse

1. When a car takes a circular turn on a level road, which force acts as the centripetal force?

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2. A particle is moving in a circle of radius r with constant angular velocity ω. At any point (r,θ) on its path , its position vector is $\overrightarrow{r}$ = r cos$\theta\hat{i} + r\sin\theta\hat{j}$. Show that the velocity of the particle has no component along the radius.

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3. Find an experssion for the acceleration of the particle and hence indicate its direction .

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4. A cyclist tilts to make an angle θ with level ground as he takes a circular turn of radius r. If the speed of the cycle is v, show that tanθ= rg/ v^2

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5. A particle of mass m moves in a circular path of radius r in a horizontal plane with uniform angular velocity $\vec{\omega}$ about the z- aixs. Write down the position vector of the particle at any instant and hence derive expressions for velocity and acceleration of the particle.

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6. Two particles having masses M and m are moving in a circular path having radii R and r respectively. If their periods are same, then the ratio of their angular velocities will be

A. $\frac{R}{r}$

B. $\sqrt{\frac{R}{r}}$

C. $\frac{r}{R}$

D. 1

Answer:

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7. Express in diagram, angular velocity, angular acceleration, linear velocity and linear acceleration as vector quantity.

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8. Why is centrifugal force called pseudo force?

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9. The maximum velocity of car which if moving in a circular path of radius 150m in horizontal plane without banking is (coefficient of friction 0.6)

A. 60 m/s

B. 30 m/s

C. 15 m/s

D. 25 m/s

Answer:

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10. If the radii of circular paths of two particles of same masses are in the ratio 1:2 , then, in order to have the same centripetal force, their velocities should be in the ratio of

A. $1:\sqrt{2}$

B. $\sqrt{2}:1$

C. $4:1$

D. $1:4$

Answer:

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11. Calculate the angular speed of a car which rounds a curve of radius 8 m at a speed of 50 km/h.

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12. The maximum speed that can be attained by a car, without skidding, on a horizontal

circular road of radius R and coefficient of kinetic friction μ is

A. μ Rg

B. $Rg\sqrt{\mu}$

C. $\mu\sqrt{Rg}$

D. $\sqrt{\mu Rg}$

Answer:

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1. A particle is moving uniformly in a circular path of radius r. When it moves through an angular displacement θ, then the magnitude of the corresponding linear displacement will be

A. $2\,r\cos\left(\frac{\theta}{2}\right)$

B. $2\,r\cot\left(\frac{\theta}{2}\right)$

C. $2\,r\tan\left(\frac{\theta}{2}\right)$

D. $2\,r\sin\left(\frac{\theta}{2}\right)$

Answer:

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2. A circular disc rolls on a horizontal floor without slipping and the centre of the disc moves with a uniform velocity v. Which of the following values the velocity at a point on the rim of the disc can have?

A. v

B. $-v$

C. 2v

D. zero

Answer:

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Examination Archive With Solutions Jee Main

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

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

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

D. $T \propto R^{\frac{n}{2}+1}$

Answer:

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1. A solid cylinder of mass 50 kg and radius 0.5 m is free to rotate about the horizontal axis. A massless string is would round the cylinder with one end attached to it and other hanging freely. Tension in the string required to produce an angular acceleration of 2 revolutions s^{-2} is

A. 25 N

B. 50 N

C. 78.5 N

D. 157 N

Answer:

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Examination Archive With Solutions Neet

1. A uniform circular disc of radius 50 cm at rest is free to turn about an axis which is perpendicular to its plane and passes through its centre. It is subjected to a torque which

produces a constant angular acceleration of 2.0 rad/s^2. Its net acceleration in m/s^2 at the end of 2.0 s is approximately

A. 7.0

B. 6.0

C. 3.0

D. 8.0

Answer:

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2. A cylist on a level road takes a sharp circular turn of radius 3m (g = 10 $m \cdot s^{-2}$). If the coefficient of static friction between the cycle tyre and the road is 0.2, at which of the following speeds will the cyclist not skid while taking the turn?

A. $14.4 \quad km \cdot h^{-1}$

B. $7.2 \quad km \cdot h^{-1}$

C. $9 \quad km \cdot h^{-1}$

D. $10.8 \quad km \cdot h^{-1}$

Answer:

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Cbse Scanner

1. Derive an expression for the acceleration of a body of mass m moving with a uniform speed v in circular path of radius r.

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2. Why are circular roads banked? Deduce an expression for maximum speed of a vehicle which can be achieved while taking a turn on the banked curved road neglecting friction.

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3. What is the need for banking of tracks? Draw free body diagram of a car negotiating a banked track [Take friction into account]. Write the expression for maximum velocity to negotiate the curve safely.

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4. Why are the spoles fitted in a cycle wheel?

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5. An insect trapped in a circular groove of radius 12 cm moves along the groove steadily and completes 7 revolutions in 100 s.

What is the angular speed and the linear speed of the motion?

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6. An insect trapped in a circular groove of radius 12 cm moves along the groove steadily and completes 7 revolutions in 100 s.

Is the acceleration vector a constant vector? What is its magnitude?

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7. Derive the expression of centripetal acceleration.

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8. Calculate the maximum speed with which a vehicle can travel on a banked circular road without skidding. A cyclist at a 18 km/h on a level road takes a sharp turn of radius 3 m without reducing the speed. The coefficient of static friction between the tyres and the road is 1. Will cyclist slip while taking the turn?

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9. Derive an expression for the maximum speed acquired by vehicle on banked circular track of radius r with coefficient of friction μ between the wheels and road.

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10. Derive an expression for the centripetal acceleration of a body moving with uniform speed v along a circular path of radius r .

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11. A stone tied to the end of a string 80 cm long is whirled in a horizontal circle with a constant speed. If the stone makes 14 revolutions in 25 s, what is the magnitude and direction of acceleration of the stone?

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