Rotational Dynamics Questions:

MCQs:

1. ***For a body undergoing rotational motion, its radius of gyration depends on***

A. Size

B. Shape

C. Axis of rotation

D. All of the above

2. A rigid body consists of a network of point masses. Which of the following about the individual mass is true, as the body rotates about an axis?

A. Each mass has the same linear acceleration.

B. Each mass has the same linear velocity.

C. Each mass has the same angular velocity and angular acceleration about the same axis.

D. All of the above.

3. In rotational motion, the physical quantity that imparts angular acceleration is, [NEB 2079]

A. Force

B. Torque

C. Moment of inertia

D. Angular Momentum

4. Which Quantity in rotational motion is analogous to force in linear motion? [NEB 2080]

A. Force

B. Torque

C. Moment of inertia

D. Angular Momentum

5. The moment of inertia of a body does not depend upon its:

A. mass

B. Angular velocity

C. Distribution of mass

D. Axes of rotation

6. Force in linear motion has its analogue in rotational motion is:

A. Angular momentum

B. Angular velocity

C. Torque

D. Moment of inertia

7. A body of moment of inertia I rotating about an axis has angular momentum L, the rotational kinetic energy of the body is,

A. $\frac{1}{2}LI$

B. $\frac{1}{2}LI^2$

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

D. $2LI$

8. Two bodies have their moment of inertia I and $2I$ respectively about their axes of rotation. If their kinetic energies of rotation are equal, their angular moment will be in the ratio,

A. $2:1$ ***C.*** $\sqrt{2}:1$

B. $1:\sqrt{2}$ ***D.*** $1:2$

9. A fan makes 10 revolutions in 3 second which is just switched on. Considering uniform acceleration the number of revolution made by fan in next 3 second is:

A. 10 ***B. 20*** ***C. 30*** ***D. 40***

10. A ring, a disc, solid sphere, hollow sphere are dropped from the same inclined plane of same height then which of the following reaches the ground first,

A. *Ring*

B. *Disc*

C. *Solid Sphere*

D. *Hollow Sphere*

11. When the size of the earth is reduced to half, mass remaining same, the time period of the earth rotation will be:

A. $6\ hours$

B. $12\ hours$

C. $24\ hours$

D. $48\ hours$

12. A flywheel rotating about a fixed axis has a kinetic energy of 225 *J when its angular speed is* $30\ rad/s$*. What is the moment of inertia of the flywheel about its axis of rotation?*

A. $0.3kgm^2$

B. $0.5kgm^2$

C. $0.6kgm^2$

D. $0.8kgm^2$

13. The moment of inertia of a body of mass M about a given axis is I. What is the radius of gyration? [MOE 2014]

A. $\frac{I}{M}$

B. IM

C. $\sqrt{\frac{I}{M}}$

D. $\sqrt{IM}$

14. Two circular rings have their masses in the ratio 1:2 and their radius are in the ratio 3:1. The ratio of their moment of inertia is:

A. $1:3$ B. 3:2 C. 9:2 D. 9:4

15. The moment of inertia of a body about a given axis is $1.2\ kg\ m^2$*. Initially, the body is at rest. In order to produce a rotating kinetic energy of* $1500\ joules$*, an angular acceleration of* $25\ rad/sec^2$ *must be applied about that axis for a duration of*

A. $2s$

B. $4s$

C. $8s$

D. $10s$

16. A wheel rotates with a constant angular acceleration of $2\ rad/s^2$*. If the wheel starts from rest the number of revolutions it makes in the first ten second will be approximately:*

A. 8

B. 16

C. 24

D. 32

17. A couple produce

A. *Purely linear motion*

B. *No rotation*

C. *Purely rotational motion*

D. *Linear and rotational motion both*

18. If a body is rotating about an axis, passing through its centre of mass then its angular momentum is directed along its

A. *Radius*

B. *Tangent*

C. *Circumference*

D. *Axis of rotation*

19. K_1 and K_2 are radii of gyrations of a uniform rod about the axes passing through its centre and one end respectively and perpendicular to its length. . $K_1 : K_2$ is equal to:

A. $\mathbf{1:1}$

B. $\mathbf{1:2}$

C. $\mathbf{2:1}$

D. $\mathbf{1:\sqrt{3}}$

20. If a gymnast on a rotating stool with his arms outstretched suddenly lowers his arms

A. The angular velocity decreases

B. The moment of inertia decreases

C. The angular velocity remains constant

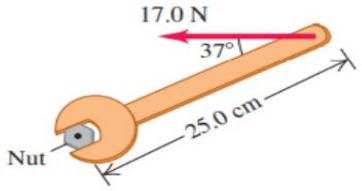
D. The angular momentum increases

SAQs: ($\mathbf{5}\ \boldsymbol{marks\ each}$) ***(Exam Style Questions)***

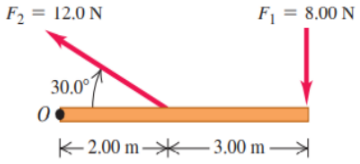
1. a) What do you mean by moment of inertia? On what factor does it depend. [2]
   b) A disc of moment of inertia $5x10^{-4}kgm^2$ is rotating freely about the axis through its centre at $40rpm$. Calculate the new revolution per minute if some wax of mass $0.02kg$ dropped gently on the disc $0.08m$ from the axis. $[Ans: 32\ rpm]$ [3]
2. a) What is the physical meaning of moment of inertia of a body? [1]
   b) A wheel starts from rest and accelerates with constant angular acceleration to an angular velocity of $15\ rev/sec$ in $10sec$. Calculate the angular acceleration and angle which the wheel has rotated at the end of $2sec$. $[Ans: 9.42\ rad/s^2, 18.84\ radian]$ [3]
3. a) Define radius of gyration. On the factors on which it depends. [2]
   b) An electric fan is turned off, and its angular velocity decreases uniformly from $500\ rev/min$ to $200\ rev/min$ in $4\ sec$. Find the angular acceleration and the number of revolutions made by the motor in the $4\ sec$ interval. How many more seconds are required for the fan to come to rest if the angular acceleration remains constant? [3]
   $[-7.85rad/s^2, 23.3, 2.68]$
4. a) What is the counterpart of the mass and force in rotational motion?
   b) What is the value of radius of gyration for uniform rod and solid sphere? [2]
   c) A disc of radius $1m$ and mass $5kg$ is rolling along a horizontal plane. Its moment of inertia about its centre is $2.5\ kgm^2$. If its velocity along the plane is $2ms^{-1}$, find its angular velocity and the total energy. $[Ans: 2\ rad/sec, 15J]$ [2]
5. a) Establish the relationship between torque and angular acceleration.
   b) A constant torque of $500Nm$ turns a wheel which has a moment of inertia $20kgm^2$ about its centre. Find the angular velocity gained in$2sec$ and the kinetic energy gained. $[50\ rad/s, 25000J]$ [3]
6. a) Define angular momentum. State the principle of conservation of angular momentum. [2]
   b) A ballet dancer spins with $2.4\ rev/s$ with her arms outstretched when the MI about the axis of rotation is I, with her arms folded, the MI about same axis becomes $0.6I$. Calculate new rate of spin. $[4rev/s]$ [3]
7. a) A ballet dancer can increase of decrease her spinning rate by using the principle of conservation of angular momentum, how? [2]
   b) A computer disc drive id turned on starting from rest and has constant angular complete acceleration, (a) how long did it take to make the first complete rotation, and (b) what is its angular acceleration? Given that the disk took $0.750sec$ for the drive to make its second complete revolution. $[Ans: 1.81sec, 3.83\ rad/sec]$ [3]
8. a) The angular velocity of the earth around the sun increases, when it comes closer to the sun, why? [2]
   b) A particle starts rotating from rest describes the angular displacement as: $\theta = \frac{3t^3}{20} - \frac{t^2}{3}$. Calculate the angular velocity and angular displacement at the end of $5sec$. [3]
9. a) Define moment of inertia of rigid body and give its unit. [1]
   b) Is the moment of inertia of a body is unique? Explain. [1]

c) Derive an expression of moment of inertia of thin uniform rod rotating about an axis passing through its centre. [3]

10. a) What is the physical significance of moment of inertia? [1]
    b) A disc and ring both having some mass and same radius. Which one has greater moment of inertia? [1]
    c) Derive an expression of moment of inertia of thin uniform rod rotating about an axis passing through its one end. [3]
11. a) Show that in rotational motion, power is the product of torque and angular velocity. [2]
    b) A heavy flywheel of moment of inertia $0.3kgm^2$ is mounted on a horizontal axle of radius $0.01m$ and having negligible mass with the flywheel. Neglecting friction, find (a) the angular acceleration if force of $40N$ is applied tangentially to the axle. (b) the angular velocity of flywheel after 10s from the rest. $[Ans: (a)1.33rads^{-2}\ (b)13.3rads^{-1}]$ [3]
12. a) Derive an expression of the work done by a couple. [2]
    b) A machinist is using a wrench to loosen a nut. The wrench is 25.0 cm long, and he exerts a 17.0 N force at the end of the handle at 37° with the handle (Fig.) (i) What torque does the machinist exert about the center of the nut? (ii) What is the maximum torque he could exert with a force of this magnitude, and how should the force be oriented? $[2.26Nm, 4.25Nm]$ [3]

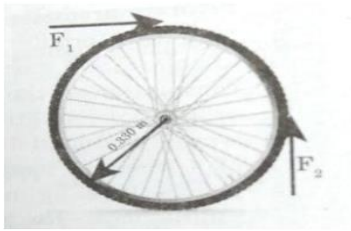


13. a) Compare the moment of inertia of two spheres one hollow other solid having same mass and radius. [2]
    b) A body is rotating, is it necessary that external torque is acting on it? [1]
    c) Calculate net torque about point O for the two forces applied as shown in fig. The rod and both forces are in the plane of the page. $[Ans: -28N]$ [2]



14. a) Apply the principle of angular momentum conservation to find duration of day if earth suddenly shrink to $\frac{1}{27}$ of its original volume and mass remains unchanged. for solid sphere. $[Ans: 2.67hrs]$ [2]

b. Forces $F_1 = 7.5N$ and $F_2 = 5.3$N are applied tangentially to a wheel with radius $0.33\ m$ as shown in fig. What is the net torque on the wheel due to these two forces for an axis perpendicular to the wheel and passing through its center? $[Ans: -0.726\ Nm]$ [3]



Reference to some short questions:

1. *Angular velocity of earth increases when it comes closer to the sun in its orbit:* ***As it come closer to sun, Its Moment of inertia decreases and to conserve angular momentum its angular velocity must Increase***
2. *If earth shrinks suddenly, what would happen to length of the day:* ***[If earth shrinks suddenly, its moment of inertial decreases (radius decreases) and from conservation of angular momentum {$I \propto 1/\omega$} its angular speed increase: length of the day decreases]***
3. *If the earth is struck by meteorites, the earth will slow down slightly:* ***[I increases, ω decreases {$I \propto 1/\omega$}, length of the day increases]***
4. *If the polar ice caps melts, what would happen to the length of the day:* ***[I increases, ω decreases {$I \propto 1/\omega$}, length of the day increases]***
5. *When tall building is constructed on earth, the duration of day night slightly increases:* ***[I increases, ω decreases {$I \propto 1/\omega$}, length of the day increases]***
6. *A Ballet dancer can increase or decrease her spinning rate by using the principle of conservation of angular momentum:* ***[From principle of conservation of angular momentum {$I \propto 1/\omega$}, she can change her spinning rate by changing moment of inertia, and moment of inertia can be changed by stretching or folding her hands]***
7. *In a flywheel, most of the mass is concentrated at the rim/ Spokes are fitted in the bicycle:* ***It increases moment of inertia, greater the moment of inertia, the more will be the opposition to any change in uniform rotational motion, as a result motion will be smooth and steady.***