Chapter 7. System of particles & rotational motion

I. One mark questions (PART – A):

1. What is translational motion? (K)
2. What is rotational motion? (K)
3. Give an example for particle having both translational and rotational motion. (U)
4. What is precession motion? (U)
5. What is the center of mass of a system of particles? (K)
6. Give the location of centre of mass of a sphere of uniform mass density? (S)
7. Give the location of centre of mass of cylinder of uniform mass density. (S)
8. Give the location of centre of mass of ring of uniform mass density? (S)
9. Give the location of centre mass of a cube of uniform mass density? (S)
10. Does the centre of mass of a body necessarily lie inside the body? (A)
11. Define average angular velocity. (K)
12. Define angular acceleration (U)
13. Is moment of force a vector or a scalar? (K)
14. What is the mechanical advantage of a lever. (K)
15. What is meant by a mechanical advantage of a lever? (K)
16. Write the expression for the torque in terms of position vector and force. (U)
17. Write the expression for the torque in terms of moment of inertia and angular acceleration. (U)
18. What is the S.I. unit of Torque? (S)
19. Write the dimensions of torque
20. Write the expression for the angular momentum in terms of linear momentum and position vector. (U)
21. Write the expression for angular momentum in terms of moment of inertia and angular velocity (U)
22. Define angular momentum (K)
23. Define a couple. (K)
24. Define moment of a couple. (U)
25. The mechanical advantage of a lever is greater than one what does it mean? (K)
26. Is moment inertia a vector or a scalar? (K)
27. Write the SI unit of moment of inertia.(U)
28. Define the term Radius of gyration (K)
29. How is Torque related to the angular momentum.(A)
30. What is the direction of angular velocity? (S)
31. Define moment of a couple.(K)
32. Name the physical quantity which is equal to the time rate of change of angular momentum.(U)
33. Give the expression for moment of Inertia of a thin rod about an axis perpendicular to the rod and passing through its mid point.(U)
34. Write the expression for the moment of inertia of a circular disc of radius R about an axis perpendicular to it and passing through its centre. (U)
35. Write the expression for the moment of inertia of a circular disc of radius R about its diameter.(U)
36. Give the expression for moment inertia of a hollow cylinder of radius R about its axis. (K)

37. Give the expression for moment of inertia of a solid cylinder of radius R about its axis. (K)

38. Give and expression for the moment of inertia of a solid sphere of radius R about its diameter.(K)

Two mark questions (PART – B):

1. Write the expression for the position vector of the centre of mass of a system consisting of two objects in terms of their masses and position vectors. (K)
2. Write an expression for position vector of centre of mass of a rigid body. (K)
   Write expression for Linear momentum of system of particles (k)
3.
4. Write a formula for instantaneous angular velocity. (K)
5. What is the relation between angular velocity and linear velocity? (U)
6. Define angular momentum. Write the expression for it.
7. Define angular acceleration. Write an expression for it.
8. Define torque. Write an expression for it. (S)
9. What is couple? Give an example for couple. (U)
10. Give the general conditions of equilibrium of a rigid body. (A)
11. Write an expression for rotational kinetic energy.. (K)
12. Write the expression for the total kinetic energy of a rolling body. (K)

13. Write one practical use of moment of inertia OR Why a fly wheel is used in an engine of a vehicle? OR What is a flywheel? (A)

Three mark questions (PART – C):

1. Find moment of inertia of rigid massless rod of length with a pair of small masses rotating about an axis through the centre of mass perpendicular to the rod.(S)
2. Explain the principle of moments for a lever. (U
3. Obtain an expression for the kinetic energy of a rotating body.(U)
4. Compare the linear motion and rotational motion(A)
5. Write the kinematic equations of a body rotating with uniform angular acceleration.(K)
6. Write the expression for the total kinetic energy of a rolling body.(K)
7. Find the torque of a force $F = 7\hat{i} + 3\hat{j} - 5\hat{k}$ about the origin. The force acts on a particle whose position vector is $r = \hat{i} - \hat{j} + \hat{k}$ Ans : $\tau = 2\hat{i} + 12\hat{j} + 10\hat{k}$ (S)

Five mark questions (PART – D):

1. State and explain theorem of perpendicular axis and of parallel axis (U)
2. Using perpendicular axis theorem obtain the expression for the moment of inertia of a disc about its diameter. (K)
3. Show that $\tau = I\alpha$. Symbols have usual meaning.(k)
4. Derive an expression for the kinetic energy of a rolling body.*(*k)

Five mark questions(numericals) (PART – D):

1. A flywheel of mass 12.5 kg and diameter 0.36m rotating at 90rpm has its speed increased to 720 rpm in 8s. Find the torque applied (Ans 1.669Nm)(S)
2. A meter stick is balanced on a knife edge at its centre. When two coins, each of mass 5g are put on the top of the other at 12.0cm mark, the stick is found to be balanced at 45cm. What is the mass of the meter stick ? (Ans 66 x 10^{-3}Kg)(S)
3. A disc of mass 200kg and radius 50cm is rotating at the rate of 480rpm. Find the work done to

bring the disc to rest. If the disc is stopped in 11 rotations, calculate retarding torque acting on the disc. (Ans : 457 Nm)

4. The angular speed of a motar wheel is increased from 1200rpm to 3120 rpm in 16 seconds. What is its angular acceleration, assuming the acceleration to be uniform ? (Ans : 4π rad/s^2)
5. The speed of a heat engine increases from 420rpm to 6360 rpm in 18 s. Calculate a) angular acceleration b) angular displacement and c) number of revolutions does it make in this period of time. (Ans : α = 34.54 rad/s^2, θ= 2034 πrad and n= 1017)
6. Find the centre of mass of three particles at the vertices of an equilateral triangle. The masses of the particles are 100g, 150g, and 200g respectively. Each side of the equilateral triangle is 0.5m long.
7. A uniform rod of length 1m and mass 20kg is supported horizontally on 2 knife edges at the ends. Two masses of 6kg and 10kg are suspended at 0.3m and 0.7m from one end of the rod. Find the reactions on the knife edges.
8. Five bodies 1kg wt., 2kg wt., 3kg wt., 4kg wt. and 5kg wt. are suspended at a distance of 1m, 2m, 3m, 4m, and 5m from one end of a uniform rod of mass 4kg and 6 metres length. Find the point about which the rod will balance about the knife edge placed at a distance of 'x' from the end A.
9. A ladder of mass 10kg and length of 4 metres rests with one end against a smooth vertical wall and the other end against a smooth floor. The ladder is inclined at 60^0 to the horizontal. Calculate the horizontal force to be applied to the lower end to prevent from sliding down. 10 seconds, calculate the angular and linear acceleration.
10. A uniform rod of mass 8kg and length 4m rotates at the rate of 60 rotations per minute about an axis passing through the centre and perpendicular to its plane. If the speed of rotation changes to 80 rpm in 10 seconds. Calculate the torque applied.
11. A cord of negligible mass is wound round the rim of a fly wheel of mass 20 kg and radius 20 cm. A steady pull of 25 N is applied on the cord as shown in Fig. The flywheel is mounted on a horizontal axle with frictionless bearings.
    (a) Compute the angular acceleration of the wheel.
    (b) Find the work done by the pull, when 2m of the cord is unwound.
    (c) Find also the kinetic energy of the wheel at this point. Assume that the wheel starts from rest.
    (d) Compare answers to parts (b) and (c).