CLASS XI – PHYSICS System of Particles and Rotational Motion

Maximum Marks: 50 Time: 2 Hours

General Instructions:

1. All questions are compulsory.
2. The question paper consists of five sections: A, B, C, D and E.
3. Use g=10 m/s2g = 10\,m/s^2, wherever required.
4. Draw neat and labelled diagrams wherever necessary.
5. Show all calculations clearly in numerical questions.
6. Use of calculators is not permitted.

Section A – Multiple Choice Questions 10 × 1 = 10 Marks

Q1. The centre of mass of a uniform circular ring lies:

(a) On its circumference (b) At its centre (c) Outside the ring (d) At any point on its diameter

Q2. The SI unit of torque is:

(a) Joule (b) Newton (c) Newton metre (d) Watt

Q3. The moment of inertia of a particle depends on:

(a) Its mass only (b) Its velocity only (c) Its angular velocity only
(d) Its mass and distance from the axis of rotation

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Q4. The angular momentum of a rotating body is given by:

(a) $I\omega$ (b) I/ω (c) $I\omega^2$ (d) $I\alpha$.

Q5. The centre of mass of two equal masses lies:

(a) At the position of first mass (b) At the position of second mass
(c) Midway between them (d) Outside the system

Q6. The rotational analogue of mass is:

(a) Torque (b) Moment of inertia (c) Angular momentum (d) Angular acceleration

Q7. If the net external torque acting on a system is zero, its angular momentum:

(a) Increases (b) Decreases (c) Remains conserved (d) Becomes zero

Q8. The moment of inertia of a thin uniform rod about an axis passing through its centre and perpendicular to its length is:

(a) $ML^2/3$ (b) $ML^2/12$ (c) $ML^2/2$ (d) ML^2.

Q9. The dimensional formula of angular momentum is:

(a) $[MLT^{-1}]$ (b) $[ML^2T^{-1}]$ (c) $[ML^2T^{-2}]$ (d) $[MLT^{-2}]$.

Q10. A couple produces:

(a) Pure translation (b) Pure rotation (c) No motion (d) Linear acceleration only

Section B – Very Short Answer Questions 5 × 2 = 10 Marks

Q11. Define centre of mass. Write the expression for the position of the centre of mass of a system of two particles.

Q12. What is meant by torque? Write its mathematical expression and SI unit.

Q13. State the principle of conservation of angular momentum. Give one example.

Q14. Define radius of gyration. Write its mathematical relation with moment of inertia.

Q15. Differentiate between linear momentum and angular momentum (any two points).

Section C – Short Answer Questions 4 × 3 = 12 Marks

Q16. Derive the expression for the centre of mass of two particles of masses m_1, m_2, situated at positions x_1, x_2.

Q17. State and explain the parallel axis theorem. Write its mathematical expression.

Q18. A wheel rotating with an angular velocity of 20 rad/s is brought to rest in 5 seconds. Calculate:

(a) Angular acceleration (b) Angular displacement during this time

Q19. Derive the relation between linear velocity and angular velocity.

Section D – Long Answer Questions 2 × 4 = 8 Marks

Q20. Derive the expression for the moment of inertia of a uniform circular ring about an axis passing through its centre and perpendicular to its plane.

OR

Derive the expression for the moment of inertia of a uniform solid disc about an axis passing through its centre and perpendicular to its plane.

Q21. Explain the theorem of perpendicular axes. Using this theorem, obtain the moment of inertia of a circular disc about a diameter.

Section E – Case-Based and Numerical Questions 2 × 5 = 10 Marks

Q22. Case Study: Conservation of Angular Momentum

A figure skater spins with her arms stretched out. When she pulls her arms close to her body, her moment of inertia decreases and her angular velocity increases. This happens because angular momentum remains conserved in the absence of external torque.

Answer the following questions:

(a) What is angular momentum? (1)

(b) Write the mathematical expression for angular momentum of a rigid body. (1)

(c) Why does the angular velocity of the skater increase when she pulls her arms inward? (2)

(d) What happens to angular momentum during this process? (1)

Q23. Numerical Problem

A solid cylinder of mass 4 kg and radius 0.5 m rotates about its own axis with an angular velocity of 10 rad/s.

Calculate:

(a) Moment of inertia of the cylinder about its axis. (2)

(b) Angular momentum of the cylinder. (1)

(c) Rotational kinetic energy of the cylinder. (2)

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