

System of Particles and Rotational Motion — CBSE Pattern Test 1

Class 11 Physics · 90 minutes · 40 marks · Sections A–D with answer key · Narayan Gurukul Academy

Test 1 — CBSE Pattern (90 minutes, 40 marks)

Class 11 Physics · System of Particles and Rotational Motion · Narayan Gurukul Academy (ClassApna)

General Instructions: (1) This paper has four sections — Section A (1×10), Section B (2×4), Section C (3×4) and Section D (5×2) — total 40 marks. Time allowed: 90 minutes.

(2) All questions are compulsory. No overall choice is given; internal choice, where allowed, is clearly marked.

(3) For MCQ questions choose the single correct option; for VSA answers write a single line.

(4) Take $g = 10 \text{ m/s}^2$. All symbols carry their usual meaning. Use of a calculator is not permitted.

Section A — MCQ & VSA ($10 \times 1 = 10$ marks)

- The centre of mass of a system of particles
 - always lies inside the body
 - may lie outside the body
 - lies at the geometric centre
 - cannot be determined for irregular bodies
- The motion of the centre of mass is governed only by
 - external forces
 - internal forces
 - both internal and external forces
 - no forces
- Two particles of masses 1 kg and 3 kg are 40 cm apart. The centre of mass is located
 - 10 cm from the 3 kg mass
 - 15 cm from the 3 kg mass
 - 20 cm from the 1 kg mass
 - at the heavier particle
- The centre of mass of a uniform rod lies
 - at its middle point
 - at one end
 - at a quarter of its length
 - outside the rod
- The SI unit of torque is
 - newton-metre (N m)
 - joule (J)
 - watt (W)
 - N m^{-2}
- Torque is maximum when the force makes an angle of
 - 90° with the position vector
 - 0° with the position vector
 - 45° with the position vector
 - 180° with the position vector
- A torque is zero when the line of action of the force
 - passes through the pivot

- (B) is perpendicular to the position vector
 - (C) is at 45° to the position vector
 - (D) is parallel to the axis
8. A couple consists of two equal and opposite forces. It produces
- (A) pure rotation only
 - (B) pure translation only
 - (C) both rotation and translation
 - (D) no motion
9. State the law of conservation of angular momentum.
10. Define the radius of gyration.

Section B — Short Answer I ($4 \times 2 = 8$ marks)

11. Two bodies of masses 2 kg and 8 kg are placed at the ends of a light rod 1 m long. Find the position of their centre of mass from the 8 kg mass.
12. A force of 10 N acts at the end of a rod of length 0.5 m, perpendicular to it. Find the torque about the pivot at the other end.
13. Two particles of masses 2 kg and 3 kg are 1 m apart. Find the position of their centre of mass.
14. Find the moment of inertia of a disc of mass 2 kg and radius 0.1 m about its own axis.

Section C — Short Answer II ($4 \times 3 = 12$ marks)

15. Three particles of masses 1 kg, 2 kg and 3 kg are placed at the vertices of an equilateral triangle of side 1 m. Find the position of the centre of mass.
16. A uniform rod of weight 40 N and length 2 m is pivoted at one end and held horizontal by a force at the other end. Find the force needed to balance the rod.
17. A flywheel of moment of inertia 2 kg m^2 rotates at 300 rpm. Find its rotational kinetic energy.
18. A solid sphere rolls down an inclined plane of height h starting from rest. Obtain the velocity of its centre of mass at the bottom.

Section D — Long Answers ($2 \times 5 = 10$ marks)

19. Obtain the relation $L = I\omega$ for the angular momentum of a rigid body rotating about a fixed axis, state the law of conservation of angular momentum, and explain with reference to a diver why tucking the body into a ball speeds up the spin.
20. State and prove the theorem of parallel axes, and apply it to find the moment of inertia of a thin rod about an axis through one end perpendicular to its length.

Answer Key (Marking Scheme)

- Q1 — (B) may lie outside the body. Q2 — (A) external forces. Q3 — (A) 10 cm from the 3 kg mass. Q4 — (A) at its middle point.
- Q5 — (A) newton-metre (N m). Q6 — (A) 90° with the position vector. Q7 — (A) passes through the pivot. Q8 — (A) pure rotation only.
- Q9 — If the net external torque on a system is zero, its total angular momentum remains constant ($L\omega = \text{constant}$).

Q10 — The distance k at which the whole mass of the body would be concentrated to give the same moment of inertia about the axis: $I = Mk^2$.

Q11 — $x_{CM} = (2 \times 1)/(2 + 8) = 0.2$ m from the 8 kg mass.

Q12 — $\tau = Fd = 10 \times 0.5 = 5$ N m.

Q13 — CM = 0.4 m from the 2 kg body (0.6 m from the 3 kg).

Q14 — $I = \frac{1}{2}MR^2 = \frac{1}{2} \times 2 \times (0.1)^2 = 0.01$ kg m².

Q15 — $x_{CM} = 3.5/6 \approx 0.58$ m; $y_{CM} = \sqrt{3}/4 \approx 0.43$ m from the vertex carrying the 1 kg mass.

Q16 — $\Sigma\tau = 0$: $F \times 2 = 40 \times 1$, so $F = 20$ N.

Q17 — $\omega = 10\pi \approx 31.4$ rad/s; $K = \frac{1}{2} \times 2 \times (10\pi)^2 = 100\pi^2 \approx 987$ J.

Q18 — $mgh = \frac{1}{2}mv^2 + \frac{1}{2}(2/5mR^2)(v^2/R^2) = (7/10)mv^2$, so $v = \sqrt{(10gh/7)}$.

Q19 — $L = \Sigma m_i r_i^2 \omega = I\omega$ with $I = \Sigma m_i r_i^2$; L is constant when $\Sigma\tau_{ext} = 0$; curling reduces I so ω increases keeping $L\omega$ constant.

Q20 — $I = I_{CM} + Md^2$; rod about one end: $d = L/2$, $I = ML^2/12 + M(L/2)^2 = ML^2/12 + ML^2/4 = ML^2/3$.