Rotational Motion

40 practice questions · NEET pattern · easy → hard

How to use it: solve each question on paper before looking at the key. Aim for 1 minute per question. Score yourself: +4 for a right answer, −1 for a wrong one. 120+ out of 160 means you are ready. Every question is new (written for this sheet); answers and one-line hints are on the last page.

Level 1 · Warm-up

1. A 3 kg particle is at x = 0 and a 1 kg particle is at x = 8 m. Where is their centre of mass?

   (1) x = 2 m (2) x = 4 m (3) x = 6 m (4) x = 1 m

2. A wheel turns at 120 rpm. Its angular speed in rad/s is

   (1) 2π (2) 4π (3) 120 (4) 12π

3. A ceiling-fan blade tip is 0.5 m from the axis and the fan turns at 20 rad/s. The speed of the tip is

   (1) 40 m/s (2) 10 m/s (3) 2.5 m/s (4) 20 m/s

4. A force of 20 N is applied at right angles to a spanner, 25 cm from the nut. The torque on the nut is

   (1) 80 N m (2) 0.5 N m (3) 50 N m (4) 5 N m

5. The moment of inertia of a thin ring of mass 2 kg and radius 0.5 m about its central axis perpendicular to its plane is

   (1) 1 kg m² (2) 0.25 kg m² (3) 0.5 kg m² (4) 2 kg m²

6. A disc with I = 0.2 kg m² spins at 10 rad/s. Its rotational kinetic energy is

   (1) 1 J (2) 10 J (3) 20 J (4) 2 J

7. The angular momentum of the disc in the previous question is

   (1) 2 kg m²/s (2) 20 kg m²/s (3) 0.02 kg m²/s (4) 1 kg m²/s

8. A uniform rod of mass 3 kg and length 2 m turns about an axis through its centre, perpendicular to it. Its moment of inertia is

   (1) 4 kg m² (2) 3 kg m² (3) 0.5 kg m² (4) 1 kg m²

9. A torque of 6 N m acts on a wheel with I = 2 kg m². Its angular acceleration is

   (1) 12 rad/s² (2) 3 rad/s² (3) 0.33 rad/s² (4) 6 rad/s²

10. A wheel starts from rest with $\alpha = 2$ rad/s². The angle it turns through in 5 s is

(1) 10 rad (2) 50 rad (3) 25 rad (4) 5 rad

11. A ball of radius 0.1 m rolls without slipping at 3 m/s. Its angular speed is

(1) 0.3 rad/s (2) 3 rad/s (3) 30 rad/s (4) 300 rad/s

12. A wheel rolls without slipping; its centre moves at 5 m/s. The speed of the topmost point is

(1) 5 m/s (2) 0 (3) 10 m/s (4) 7.1 m/s

13. A spinning skater pulls her arms in so that her moment of inertia halves. Her angular speed

(1) halves (2) doubles
(3) stays the same (4) becomes four times

14. A ring, a disc, a solid sphere and a hollow sphere have the same mass and radius. Which has the largest moment of inertia about its own symmetry axis?

(1) solid sphere (2) disc (3) hollow sphere (4) ring

Level 2 · NEET standard

15. Masses of 1 kg, 1 kg and 2 kg are at (0, 0), (3 m, 0) and (0, 3 m). The centre of mass is at

(1) (1 m, 1 m) (2) (0.75 m, 1.5 m) (3) (1.5 m, 0.75 m) (4) (1 m, 1.5 m)

16. From a uniform disc of radius R, a disc of radius R/2 is cut out, touching the centre O. The centre of mass of the rest is

(1) R/6 from O, away from the hole (2) R/6 from O, towards the hole
(3) R/4 from O, away from the hole (4) R/3 from O, away from the hole

17. A wheel slows uniformly from 600 rpm to 300 rpm in 10 s. How many revolutions does it make in that time?

(1) 50 (2) 100 (3) 150 (4) 75

18. A point on a rim of radius 0.2 m has $\omega = 10$ rad/s and $\alpha = 50$ rad/s² at an instant. Its net acceleration is about

(1) 20 m/s² (2) 10 m/s² (3) 22.4 m/s² (4) 30 m/s²

19. A force $\vec{F} = (2\hat{i} + 3\hat{j})$ N acts at $\vec{r} = (\hat{i} + 2\hat{j})$ m. The torque about the origin is

(1) $\hat{k}$ N m (2) $-\hat{k}$ N m (3) $7\hat{k}$ N m (4) $-7\hat{k}$ N m

20. A uniform metre rule balances at its 50 cm mark. A 50 g mass hangs at the 10 cm mark. Where must a 100 g mass hang to keep it balanced?

(1) 70 cm mark (2) 60 cm mark (3) 80 cm mark (4) 90 cm mark

21. A 2 kg particle moves at 4 m/s along the line $y = 3$ m, parallel to the x-axis. The size of its angular momentum about the origin is

(1) 8 kg m²/s (2) 12 kg m²/s (3) 0 (4) 24 kg m²/s

22. A disc spins freely at ω. An identical disc at rest is dropped onto it, on the same axis, and they stick. The fraction of kinetic energy lost is

(1) $\frac{1}{4}$ (2) $\frac{1}{2}$ (3) $\frac{3}{4}$ (4) 0

23. A uniform rod of mass M and length L turns about a perpendicular axis through a point L/4 from one end. Its moment of inertia is

(1) $\frac{ML^2}{3}$ (2) $\frac{ML^2}{16}$ (3) $\frac{5ML^2}{48}$ (4) $\frac{7ML^2}{48}$

24. The moment of inertia of a uniform disc (mass M, radius R) about a tangent in its own plane is

(1) $\frac{1}{2}MR^2$ (2) $\frac{1}{4}MR^2$ (3) $\frac{5}{4}MR^2$ (4) $\frac{3}{2}MR^2$

25. The radius of gyration of a solid sphere of radius 10 cm about a diameter is about

(1) 4 cm (2) 6.3 cm (3) 8.2 cm (4) 10 cm

26. A flywheel with $I = 4$ kg m² is brought from rest to 10 rad/s. The work needed is

(1) 40 J (2) 200 J (3) 400 J (4) 20 J

27. A 2 kg block hangs from a light string wound on a fixed pulley that is a uniform disc of mass 4 kg and radius 0.2 m. The block's acceleration is ($g = 10$ m/s²)

(1) 10 m/s² (2) 5 m/s² (3) 6.7 m/s² (4) 2.5 m/s²

28. For a ring rolling without slipping, the fraction of its kinetic energy that is rotational is

(1) $\frac{1}{3}$ (2) $\frac{2}{7}$ (3) $\frac{1}{2}$ (4) $\frac{2}{5}$

29. A solid sphere rolls without slipping from rest down a slope of height 1.4 m. Its speed at the bottom is ($g = 10\ m/s^2$)

(1) $\sqrt{28}$ m/s (2) $\sqrt{20}$ m/s (3) $\sqrt{14}$ m/s (4) $\sqrt{10}$ m/s

30. A solid cylinder rolls without slipping with total kinetic energy 30 J. Its translational kinetic energy is

(1) 10 J (2) 15 J (3) 20 J (4) 25 J

Level 3 · Hard

31. A 60 kg man stands at one end of a 40 kg boat, 5 m long, on still water. He walks to the other end. How far does the boat move?

(1) 2 m (2) 5 m (3) 2.5 m (4) 3 m

32. A uniform rod of length L, hinged at one end, is released from the horizontal. The speed of its free end as it passes the vertical is

(1) $\sqrt{(gL)}$ (2) $\sqrt{(2gL)}$ (3) $\sqrt{(3gL)}$ (4) $\sqrt{(6gL)}$

33. For the rod in the previous question, the linear acceleration of the free end just after release is

(1) g (2) $\frac{3g}{2}$ (3) $\frac{2g}{3}$ (4) $\frac{g}{2}$

34. Two discs with moments of inertia I and 2I spin in the same sense at ω and 2ω. They are pressed together on a common axis. Their common angular speed is

(1) $\frac{3\omega}{2}$ (2) $\frac{5\omega}{3}$ (3) $\frac{4\omega}{3}$ (4) ω

35. In the previous question, the kinetic energy lost is

(1) $\frac{I\omega^2}{3}$ (2) $\frac{I\omega^2}{6}$ (3) $\frac{I\omega^2}{2}$ (4) $\frac{2I\omega^2}{3}$

36. Four particles of mass m sit at the corners of a square of side a. The moment of inertia about a diagonal is

(1) $2ma^2$ (2) $\frac{ma^2}{2}$ (3) $4ma^2$ (4) ma^2

37. A thin uniform wire of mass M is bent into a square of side a. Its moment of inertia about an axis through the centre, perpendicular to the square, is

(1) $\frac{Ma^2}{3}$ (2) $\frac{Ma^2}{12}$ (3) $\frac{Ma^2}{6}$ (4) $\frac{2Ma^2}{3}$

38. A solid cylinder rolling without slipping and a block sliding without friction start up the same slope with the same speed. Ratio of heights reached, cylinder : block, is

(1) 1 : 1 (2) 3 : 2 (3) 2 : 3 (4) 7 : 5

39. A solid sphere and a hollow sphere of the same mass and radius roll from rest down the same slope. Ratio of their times to reach the bottom, $t_{solid} : t_{hollow}$, is

(1) $\sqrt{21} : 5$ (2) $5 : \sqrt{21}$ (3) 21 : 25 (4) 1 : 1

40. The least coefficient of friction that lets a solid cylinder roll without slipping down a slope of angle θ is

(1) $\frac{\tan\theta}{2}$ (2) $\frac{2\tan\theta}{7}$ (3) $\tan\theta$ (4) $\frac{\tan\theta}{3}$

Answer key and hints

1. (1) $x_{cm} = (3\cdot0 + 1\cdot8)/4 = 2$ m, nearer the heavier mass.
2. (2) $120 \times 2\pi/60 = 4\pi$ rad/s.
3. (2) $v = \omega r = 20 \times 0.5 = 10$ m/s.
4. (4) $\tau = rF = 0.25 \times 20 = 5$ N m.
5. (3) $I = MR^2 = 2 \times 0.25 = 0.5$ kg m².
6. (2) $\tfrac{1}{2}I\omega^2 = \tfrac{1}{2} \times 0.2 \times 100 = 10$ J.
7. (1) $L = I\omega = 0.2 \times 10 = 2$ kg m²/s.
8. (4) $ML^2/12 = 3 \times 4/12 = 1$ kg m².
9. (2) $\alpha = \tau/I = 6/2 = 3$ rad/s².
10. (3) $\theta = \tfrac{1}{2}\alpha t^2 = \tfrac{1}{2} \times 2 \times 25 = 25$ rad.
11. (3) $\omega = v/R = 3/0.1 = 30$ rad/s.
12. (3) Top point: $v + \omega R = 2v = 10$ m/s.
13. (2) No external torque: $I\omega$ constant, so $I/2 \rightarrow 2\omega$.
14. (4) All the ring's mass is at R: MR^2 is the largest.
15. (2) $x = 3/4$, $y = 6/4$: divide by the total mass 4 kg.
16. (1) $-(\tfrac{1}{4} \times R/2)/(\tfrac{3}{4}) = -R/6$: the CM moves away from the hole.
17. (4) Average 450 rpm × (10/60) min = 75 revolutions.
18. (3) $a_c = \omega^2 r = 20$, $a_t = \alpha r = 10$, $\sqrt{(20^2 + 10^2)} \approx 22.4$.
19. (2) $r \times F = (1\cdot3 - 2\cdot2)\,\hat{k} = -\hat{k}$.
20. (1) $50 \times 40 = 100 \times d \Rightarrow d = 20$ cm right of the centre.
21. (4) $L = mvr_{\perp} = 2 \times 4 \times 3 = 24$.
22. (2) $I\omega = 2I\omega' \Rightarrow \omega' = \omega/2$; KE goes from $\tfrac{1}{2}I\omega^2$ to $\tfrac{1}{4}I\omega^2$.
23. (4) $ML^2/12 + M(L/4)^2 = 7ML^2/48$ (parallel axis).
24. (3) Diameter $\tfrac{1}{4}MR^2$, then shift by R: $\tfrac{1}{4} + 1 = 5/4$.
25. (2) $k = \sqrt{(2/5)}\,R \approx 0.632 \times 10$ cm.
26. (2) $W = \Delta KE = \tfrac{1}{2} \times 4 \times 100 = 200$ J.
27. (2) $a = mg/(m + I/R^2) = 20/(2 + 2) = 5$ m/s².
28. (3) $k^2/R^2 = 1$: share $= 1/(1 + 1) = \tfrac{1}{2}$.
29. (2) $v^2 = 2gh/(1 + 2/5) = 28/1.4 = 20$.
30. (3) Translational share $= 1/(1 + \tfrac{1}{2}) = 2/3$ of 30 J.
31. (4) CM stays put: boat moves $mL/(M + m) = 300/100 = 3$ m.
32. (3) $Mg(L/2) = \tfrac{1}{2}(ML^2/3)\omega^2 \Rightarrow \omega^2 = 3g/L$, $v = \omega L$.
33. (2) $\alpha = (MgL/2)/(ML^2/3) = 3g/2L$; $a = \alpha L = 3g/2$.
34. (2) $(I\omega + 2I\cdot2\omega)/(3I) = 5\omega/3$.
35. (1) Before $4.5I\omega^2$, after $\tfrac{1}{2}\cdot3I\cdot(5\omega/3)^2 = 25I\omega^2/6$: loss $I\omega^2/3$.
36. (4) Two masses on the axis; two at $a/\sqrt{2}$: $2m(a^2/2) = ma^2$.
37. (1) Each side: $(M/4)(a^2/12 + a^2/4) = Ma^2/12$; four sides.
38. (2) Cylinder: $\tfrac{3}{4}v^2 = gh$; block: $\tfrac{1}{2}v^2 = gh$. Ratio $\tfrac{3}{4} : \tfrac{1}{2}$.
39. (1) $t \propto \sqrt{(1 + k^2/R^2)}$: $\sqrt{(7/5)} : \sqrt{(5/3)} = \sqrt{21} : 5$.
40. (4) $f = mg \sin\theta - ma = \tfrac{1}{3}mg \sin\theta \le \mu\, mg \cos\theta$.