

STUDYNEST | CLASS 11 PHYSICS QUESTION PAPER 1

Chapter 6: System of Particles and Rotational Motion

Maximum Marks: 40 | Suggested time: 60 minutes

Instructions: Answer all questions. Show calculation steps and units. Original practice paper, not an official examination.

Section A 1-mark questions - $8 \times 1 = 8$ marks

1. Define centre of mass. [1]
2. Torque magnitude? [1]
3. SI unit of moment of inertia? [1]
4. Rotational kinetic energy? [1]
5. Condition for angular momentum conservation? [1]
6. Rolling relation? [1]
7. Static rigid-body equilibrium? [1]
8. Parallel-axis theorem? [1]

Section B 2-mark questions - $6 \times 2 = 12$ marks

9. 2 and 3 kg at $x=0$ and 5 m: x_{cm} ? [2]
10. 4 N perpendicular at .5 m: torque? [2]
11. $I=3 \text{ kg m}^2$, $\omega=4$: rotational energy? [2]
12. Radius .4 m wheel at 8 m/s: ω ? [2]
13. Torque 12 N m and $I=4$: ? [2]
14. No external force: total momentum? [2]

Section C 3-mark questions - $4 \times 3 = 12$ marks

15. 2 kg at $x=0$ and 6 kg at $x=4$: x_{cm} ? [3]
16. .25 m spanner, 40 N at 30: torque? [3]
17. Solid disc $M=4 \text{ kg}$, $R=.5 \text{ m}$: I and KE at $\omega=10$? [3]
18. ω rises 2 to 10 rad/s in 4 s: and θ ? [3]

Section D 4-mark questions - $2 \times 4 = 8$ marks

19. 2 kg at $x=0$ and 3 kg at $x=5 \text{ m}$, external force 10 N: x_{cm} and acceleration? [4]
20. Skater I changes 4 to 1.6 kg m^2 from $\omega=3$: final ω and KE change? [4]

End of question paper.

FORMULA AND EQUATION REFERENCE

Chapter-specific equations worth knowing

- Centre of mass on a line: $x_{cm} = (\sum m_i x_i) / (\sum m_i)$.
- Torque magnitude: $\tau = rF \sin(\theta)$; rotational equilibrium requires $\sum \tau = 0$.
- Moment of inertia: $I = \sum m_i r_i^2$; solid disc about centre: $I = (1/2)MR^2$.
- Rotational kinetic energy $K = (1/2)I \omega^2$; angular momentum $L = I \omega$.
- Angular kinematics: $\alpha = (\omega_f - \omega_i) / t$; $\theta = \omega_i t + (1/2)\alpha t^2$; $\theta = ((\omega_i + \omega_f) / 2)t$.
- Rolling without slipping: $v = R \omega$. Parallel-axis theorem: $I = I_{cm} + Md^2$.
- Angular momentum conservation: $I_i \omega_i = I_f \omega_f$ when external torque is zero.
- Translation: $a = F_{net} / M$ for the whole system.

Use each equation only when its assumptions apply; keep units consistent.

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STEP-BY-STEP SOLUTIONS

Solutions are grouped here after the question paper and formula reference.

Question 1

Principle / definition: Recall the relevant definition or equation from the formula reference.

Apply it to this question: Mass-weighted mean position.

Final answer: Mass-weighted mean position.

Question 2

Principle / definition: Recall the relevant definition or equation from the formula reference.

Apply it to this question: $rF \sin\theta$.

Final answer: $rF \sin\theta$.

Question 3

Principle / definition: Recall the relevant definition or equation from the formula reference.

Apply it to this question: kg m^2 .

Final answer: kg m^2 .

Question 4

Principle / definition: Recall the relevant definition or equation from the formula reference.

Apply it to this question: $I\omega^2$.

Final answer: $I\omega^2$.

Question 5

Principle / definition: Recall the relevant definition or equation from the formula reference.

Apply it to this question: Net external torque is zero.

Final answer: Net external torque is zero.

Question 6

Principle / definition: Recall the relevant definition or equation from the formula reference.

Apply it to this question: $v=r\omega$.

Final answer: $v=r\omega$.

Question 7

Principle / definition: Recall the relevant definition or equation from the formula reference.

Apply it to this question: $F=0$ and $\tau=0$.

Final answer: $F=0$ and $\tau=0$.

Question 8

Principle / definition: Recall the relevant definition or equation from the formula reference.

Apply it to this question: $I=I_{\text{cm}}+Md^2$.

Final answer: $I=I_{\text{cm}}+Md^2$.

Question 9

Working: $x_{\text{cm}}=(m_1x_1+m_2x_2)/(m_1+m_2)=[2(0)+3(5)]/(2+3)=15/5=3 \text{ m}$.

Final answer: 3 m.

Question 10

Working: Torque magnitude $\tau=rF \sin 90=0.5(4)=2 \text{ N m}$.

Final answer: 2 N m.

Question 11

Working: $K_{\text{rot}}=0.5 I \omega^2=0.5(3)(4^2)=1.5(16)=24 \text{ J}$.

Final answer: 24 J.

Question 12

Working: For rolling without slipping, $\omega=v/r=8/0.4=20 \text{ rad/s}$.

Final answer: 20 rad/s.

Question 13

Working: Angular acceleration $\alpha=\tau/I=12/4=3 \text{ rad/s}^2$.

Final answer: 3 rad/s².

Question 14

Working: With zero net external force, momentum of the complete system remains constant: total $p_{\text{initial}}=\text{total } p_{\text{final}}$.

Final answer: Constant.

Question 15

Working: $x_{cm} = [2(0) + 6(4)] / (2+6) = 24/8 = 3$ m.

Final answer: 3 m.

Question 16

Working: $\tau = rF \sin(\theta) = 0.25(40)\sin 30 = 10(0.5) = 5$ N m.

Final answer: 5 N m.

Question 17

Working: For a solid disc $I = 0.5MR^2 = 0.5(4)(0.5^2) = 0.5$ kg m². $K = 0.5I\omega^2 = 0.25(100) = 25$ J.

Final answer: $I = 0.5$ kg m²; $K = 25$ J.

Question 18

Working: $\alpha = (10-2)/4 = 2$ rad/s². Angular displacement = average angular speed x time = $((2+10)/2)(4) = 6(4) = 24$ rad.

Final answer: 2 rad/s²; 24 rad.

Question 19

Working: $x_{cm} = [2(0) + 3(5)]/5 = 3$ m. Total mass = 5 kg, so acceleration of the centre of mass $a = F/M = 10/5 = 2$ m/s².

Final answer: 3 m; 2 m/s².

Question 20

Working: With no external torque, $I_i\omega_i = I_f\omega_f$. Thus $\omega_f = (4)(3)/1.6 = 7.5$ rad/s. $K_i = 0.5(4)(3^2) = 18$ J; $K_f = 0.5(1.6)(7.5^2) = 45$ J, an increase of 27 J supplied by the skater's work.

Final answer: $\omega = 7.5$ rad/s; K increases 18 to 45 J because skater does work.

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