

Moment of inertia by integration and torque

AP Physics C (Mechanics and E&M, calculus-based) · Test

Name: _____ Date: _____ Class: _____ Mark: ____ / 20

This test covers moment of inertia by integration, the parallel axis theorem, torque, rotational dynamics and conservation of angular momentum. Show your working and give units. Use $g = 9.81 \text{ m/s}^2$. The time limit is 45 minutes and you may use a calculator.

Level: AP Physics C (Mechanics and E&M, calculus-based) · **Curriculum:** AP PC:M Unit 5

Time: 45 minutes · 8 questions · Total: 20 marks · Calculator allowed

Question 1 Moment of inertia (2 marks)

- Define the moment of inertia of a body about an axis. (1 mark)
- State the equation that links net torque, moment of inertia and angular acceleration. (1 mark)

Question 2 Rod by integration (3 marks)

A uniform rod of mass 0.50 kg and length 0.60 m rotates about an axis perpendicular to it through one end.

- Write dm in terms of dx . (1 mark)
- Evaluate $I = \int x^2 dm$. (1 mark)
- Calculate I . (1 mark)

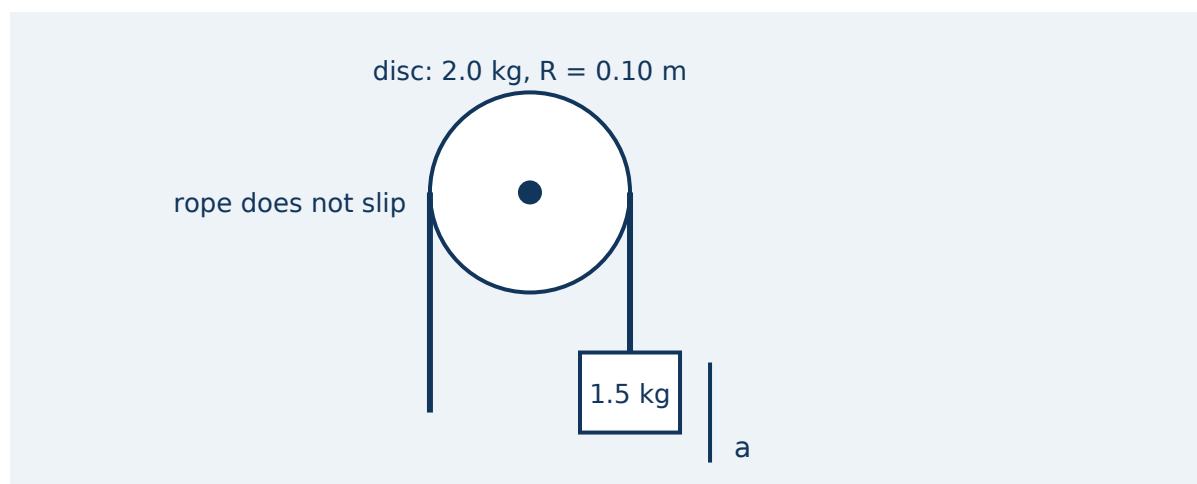
Question 3 Parallel axis (3 marks)

The same rod has $I_{\text{cm}} = ML^2/12$ about its centre.

- Calculate I_{cm} . (1 mark)
- State the parallel axis theorem. (1 mark)
- Calculate I about a parallel axis 0.20 m from the centre. (1 mark)

Question 4 Pulley and mass (4 marks)

A 1.5 kg mass hangs from a rope wrapped around a solid disc pulley of mass 2.0 kg and radius 0.10 m, as shown.



Hanging mass driving a pulley.

- Write the equations of motion for the mass and for the pulley. (1 mark)
- Calculate the acceleration of the mass. (1 mark)
- Calculate the tension in the rope. (1 mark)
- Calculate the angular acceleration of the pulley. (1 mark)

Question 5 Braking a flywheel (3 marks)

A flywheel with $I = 0.80 \text{ kg}\cdot\text{m}^2$ spins at 50 rad/s . A brake applies a constant torque of $20 \text{ N}\cdot\text{m}$.

- Calculate the angular deceleration. (1 mark)
- Calculate the time to stop. (1 mark)
- Calculate the kinetic energy removed. (1 mark)

Question 6 Hoop and disc (2 marks)

A hoop and a solid disc of equal mass and radius are released together from rest at the top of an incline and roll without slipping. State which reaches the bottom first and explain using moment of inertia. (2 marks)

Question 7 Spinning skater (2 marks)

Explain, using angular momentum, why a skater spins faster when she pulls her arms in, and calculate the factor if her moment of inertia halves. (2 marks)

Question 8 Disc formula (1 mark)

State the moment of inertia of a uniform solid disc of mass M and radius R about its central axis. (1 mark)