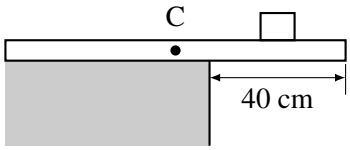
AP PHYSICS C: ROTATIONAL MOTION

Directions: Each of the questions or incomplete statements below is followed by five suggested answers or completions. Select the one that is best in each case and place the letter of your choice in the corresponding box on the student answer sheet.

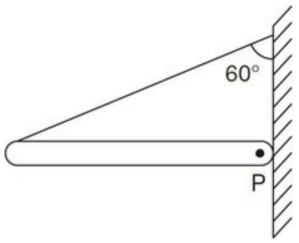
Note: To simplify calculations, you may use $g = 10\,\text{m/s}^2$ in all problems.

1. A meter stick of mass 0.1 kg rests on a table as shown. A length of 40 cm extends over the edge of the table. How far from the edge of the table could a 0.05 kg mass be placed on the meter stick so that the stick just begins to tip?



(A) 5 cm
(B) 10 cm
(C) 15 cm
(D) 20 cm
(E) 30 cm

2. A metal bar of constant density and weight W is attached to a pivot on the wall at point P and supported by a rope that makes an angle of 60° with the vertical wall. The reaction force exerted by the pivot on the bar at point P is best represented by which arrow?

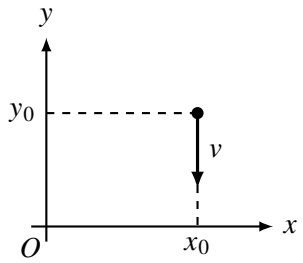


(A) ↗
(B) ↑
(C) ↓
(D) ↖
(E) ↘

3. A ballet dancer is spinning around a vertical axis with her arms fully extended. How are her angular momentum and kinetic energy affected as she pulls her arms in toward her body as she spins?

(A) Her angular momentum remains constant, but her kinetic energy increases.
(B) Her angular momentum increases, but her kinetic energy remains constant.
(C) Her angular momentum decreases, but her kinetic energy remains constant.
(D) Her angular momentum increases, but her kinetic energy decreases.
(E) Both her angular momentum and kinetic energy remain constant.

4. A particle of mass m moves with a constant speed v at a distance x_0 parallel to the y-axis as shown. When the particle is in the position shown below, the magnitude of its angular momentum relative to the origin is



(A) mvx_0
(B) mvy_0
(C) $mv\sqrt{x_0^2 + y_0^2}$
(D) $\dfrac{mv}{\sqrt{x_0^2 + y_0^2}}$
(E) zero

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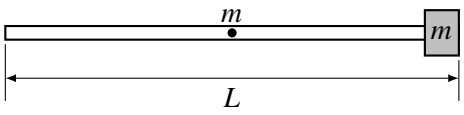
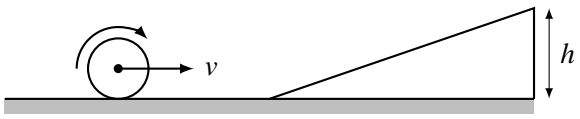
5. A uniform rod of length L and mass m has a rotational inertia of $\frac{1}{12}mL^2$ about its center. A particle, also of mass m, is attached to one end of the stick. The combined rotational inertia of the stick and particle about the center of the rod is



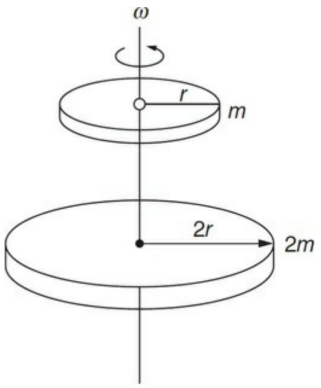
(A) $\frac{mL^2}{3}$
(B) $\frac{12mL^2}{13}$
(C) $\frac{13mL^2}{12}$
(D) $\frac{mL^2}{156}$
(E) $\frac{13mL^2}{156}$

6. A hoop of radius R and mass m has a rotational inertia of mR^2. The hoop rolls without slipping along a horizontal floor with a constant speed v and then rolls up a long incline. The hoop can roll up the incline to a maximum vertical height of



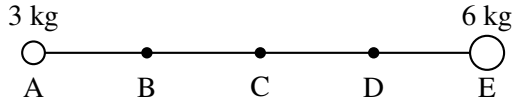
(A) $\frac{v^2}{g}$
(B) $\frac{2v^2}{g}$
(C) $\frac{v^2}{2g}$
(D) $\frac{4v^2}{g}$
(E) $\frac{v^2}{4g}$

7. Two disks are fixed to a vertical axle that is rotating with a constant angular speed ω. The smaller disk has a mass m and a radius r, and the larger disk has a mass $2m$ and radius $2r$. The general equation for the rotational inertia of a disk of mass M and radius R is $\frac{1}{2}MR^2$. The ratio of the angular momentum of the larger disk to the smaller disk is



(A) 1 : 4
(B) 4 : 1
(C) 1 : 2
(D) 2 : 1
(E) 8 : 1

8. A light rod has a mass attached at each end. At one end is a 6 kg mass, and at the other end is a 3 kg mass. An axis can be placed at any of the points shown. Through which point should an axis be placed so that the rotational inertia is the greatest about that axis?



(A) A
(B) B
(C) C
(D) D
(E) E

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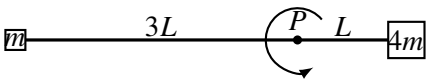
9. A light rod of negligible mass is pivoted at point P a distance L from one end as shown. A mass m is attached to the left end of the rod at a distance of $3L$ from the pivot, and another mass $4m$ is attached to the other end a distance L from the pivot. The system begins from rest in the horizontal position. The net torque acting on the system due to gravitational forces is

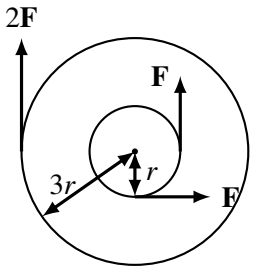


(A) $4mgL$ clockwise
(B) $3mgL$ clockwise
(C) $3mgL$ counterclockwise
(D) mgL counterclockwise
(E) mgL clockwise

10. The angular acceleration of the system when it is released from rest is

(A) zero
(B) $\frac{g}{5L}$
(C) $\frac{g}{4L}$
(D) $\frac{g}{13L}$
(E) $\frac{g}{L}$

11. Two wheels are attached to each other and fixed so that they can only turn together. The smaller wheel has a radius of r and the larger wheel has a radius of $3r$. The two wheels can rotate together on a frictionless axle. Three forces act tangentially on the edge of the wheels as shown. The magnitude of the net torque acting on the system of wheels is



(A) Fr
(B) $2Fr$
(C) $3Fr$
(D) $4Fr$
(E) $6Fr$

12. A disk is mounted on a fixed axle. The rotational inertia of the disk is I. The angular velocity of the disk is decreased from ω_i to ω_f during a time Δt due to friction in the axle. The magnitude of the average net torque acting on the wheel is

(A) $\frac{\omega_f - \omega_i}{\Delta t}$
(B) $\frac{(\omega_f - \omega_i)^2}{\Delta t}$
(C) $\frac{I(\omega_f - \omega_i)}{\Delta t}$
(D) $\frac{I(\omega_f - \omega_i)^2}{\Delta t}$
(E) $\frac{I(\omega_f - \omega_i)}{\Delta t^2}$

13. The average power developed by the friction in the axle of the disk from the previous question to bring it to a complete stop is

(A) $\frac{\omega_i}{\Delta t}$
(B) $\frac{(\omega_i)^2}{\Delta t}$
(C) $\frac{I\omega_i}{2\Delta t}$
(D) $\frac{I\omega_i^2}{2\Delta t}$
(E) $\frac{I\omega_i}{\Delta t^2}$

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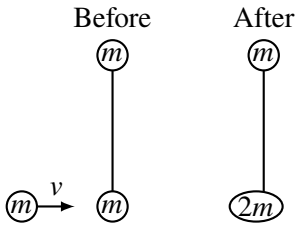
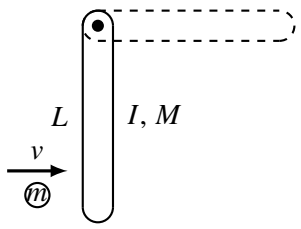
14. Astronauts are conducting an experiment in a negligible gravity environment. Two spheres of mass m are attached to either end of a light rod. As the rod and spheres float motionless in space, an astronaut launches a piece of sticky clay, also of mass m, toward one of the spheres so that the clay strikes and sticks to the sphere perpendicular to the rod. Which of the following statements is true of the motion of the rod, clay, and spheres after the collision?



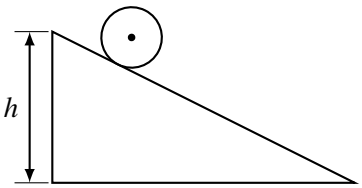
(A) Linear momentum is not conserved, but angular momentum is conserved.
(B) Angular momentum is not conserved, but linear momentum is conserved.
(C) Kinetic energy is conserved, but angular momentum is not conserved.
(D) Kinetic energy is conserved, but linear momentum is not conserved.
(E) Both linear momentum and angular momentum are conserved, but kinetic energy is not conserved.

15. A rod of mass M, length L, and rotational inertia I hangs at rest from a frictionless axle as shown. A ball of mass m with a speed v strikes the rod perpendicularly at the end of the rod. As a result of the collision, the ball stops. The angular speed of the rod immediately after the collision is



(A) vL
(B) $\dfrac{v}{L}$
(C) $\dfrac{mv}{I}$
(D) $\dfrac{mvL}{I}$
(E) $\dfrac{mv}{IL}$

Questions ??–?? A hollow sphere of mass m and radius R begins from rest at a height h and rolls down a rough inclined plane. The rotational inertia of the hollow sphere is $\dfrac{2}{3}mR^2$.



16. Which of the following diagrams best represents the forces acting on the sphere as it rolls down the plane?

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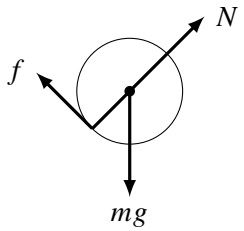
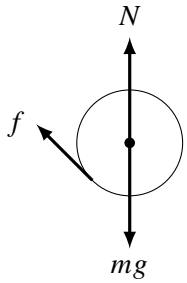
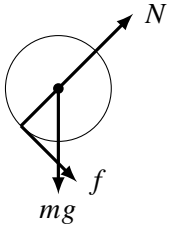


(B)


(C)


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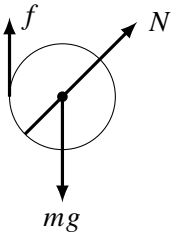

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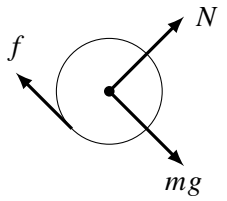

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17. The speed of the sphere when it reaches the bottom of the plane is

(A) $\frac{8gh}{5}$

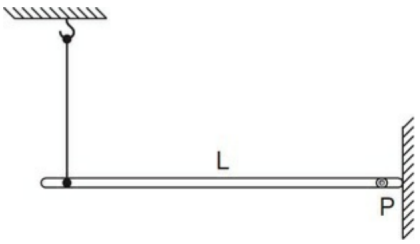
(B) $\frac{6gh}{5}$

(C) $\frac{5gh}{6}$

(D) $\frac{7gh}{10}$

(E) $\frac{gh}{2}$

18. One end of a stick of length L, rotational inertia I, and mass m is pivoted on an axle with negligible friction at point P. The other end is tied to a string and held in a horizontal position. When the string is cut, the stick rotates counterclockwise. The angular speed ω of the stick when it reaches the bottom of its swing is



(A) $\frac{mgL}{I}$

(B) $\sqrt{\frac{mgL}{I}}$

(C) $\sqrt{\frac{2mgL}{I}}$

(D) $\sqrt{\frac{mgL}{2I}}$

(E) $\sqrt{\frac{4mgL}{I}}$

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