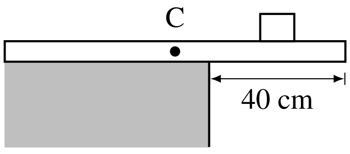
Student #: ____________________________ Student Name: ___________________________________

AP PHYSICS C CLASS 7: ROTATIONAL MOTION, PART 1

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.

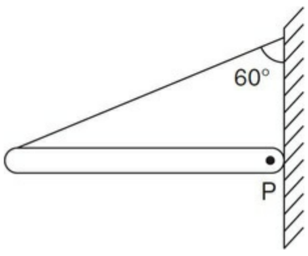
Note: To simplify calculations, you may use $g = 10\,\text{m/s}^2$ in all problems.

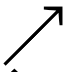
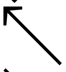
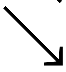
1. A meter stick of mass 0.1 kg rests on a table as shown. A length of 40 cm extends over the edge of the table. How far from the edge of the table could a 0.05 kg mass be placed on the meter stick so that the stick just begins to tip?



(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?

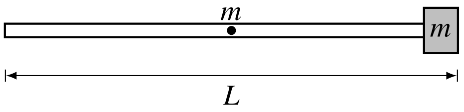


(A) 
(B) 
(C) 
(D) 
(E) 

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?

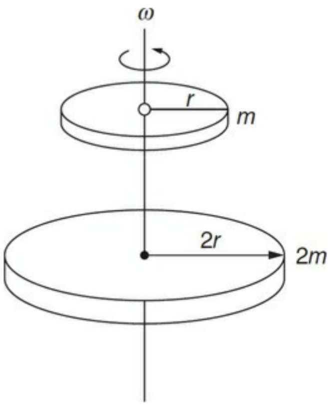
(A) Her angular momentum remains constant, but her kinetic energy increases.
(B) Her angular momentum increases, but her kinetic energy remains constant.
(C) Her angular momentum decreases, but her kinetic energy remains constant.
(D) Her angular momentum increases, but her kinetic energy decreases.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

4. A 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



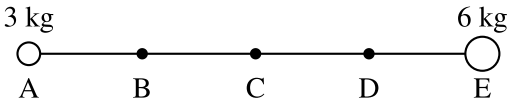
(A) $\dfrac{mL^2}{3}$
(B) $\dfrac{12mL^2}{13}$
(C) $\dfrac{13mL^2}{12}$
(D) $\dfrac{mL^2}{156}$
(E) $\dfrac{13mL^2}{156}$

5. 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

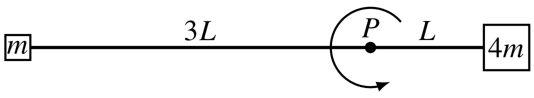
6. A light rod has a mass attached at each end. At one end is a 6 kg mass, and at the other end is a 3 kg mass. An axis can be placed at any of the points shown. Through which point should an axis be placed so that the rotational inertia is the greatest about that axis?



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

Question 7–8

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.



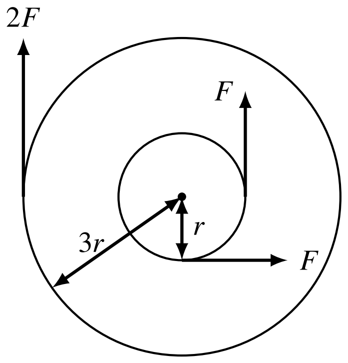
7. The net torque acting on the system due to gravitational forces is

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

8. 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) $\frac{g}{L}$

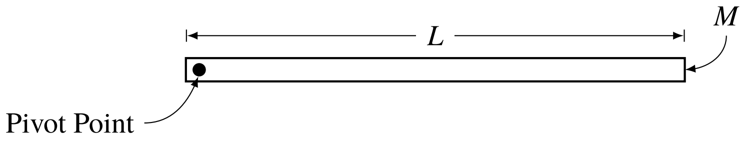
9. Two wheels are attached to each other and fixed so that they can only turn together. The smaller wheel has a radius of r and the larger wheel has a radius of $3r$. The two wheels can rotate together on a frictionless axle. Three forces act tangentially on the edge of the wheels as shown. The magnitude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



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

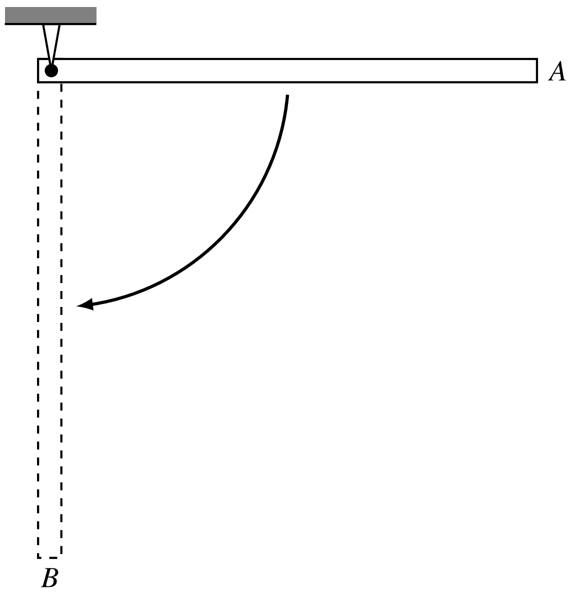
AP PHYSICS C CLASS 7: ROTATIONAL MOTION, PART 1
SECTION II
2 Questions

Directions: Answer all questions. The parts within a question may not have equal weight. All final numerical answers should include appropriate units. Credit depends on the quality of your solutions and explanations, so you should show your work. Credit also depends on demonstrating that you know which physical principles would be appropriate to apply in a particular situation. Therefore, you should clearly indicate which part of a question your work is for.



1. A uniform, thin rod of length L and mass M is allowed to pivot about its end, as shown in the figure above.

   (a) Using integral calculus, derive the rotational inertia for the rod around its end to show that it is $ML^2/3$.



The rod is fixed at one end and allowed to fall from the horizontal position A through the vertical position B.

(b) Derive an expression for the velocity of the free end of the rod at position B. Express your answer in terms of M, L, and physical constants, as appropriate.

An experiment is designed to test the validity of the expression found in part (b). A student uses rods of various lengths that all have a uniform mass distribution. The student releases each of the rods from the horizontal position A and uses photogates to measure the velocity of the free end at position B. The data are recorded below.

Length (m)	0.25	0.50	0.75	1.00	1.25	1.50
Velocity (m/s)	2.7	3.8	4.6	5.2	5.8	6.3

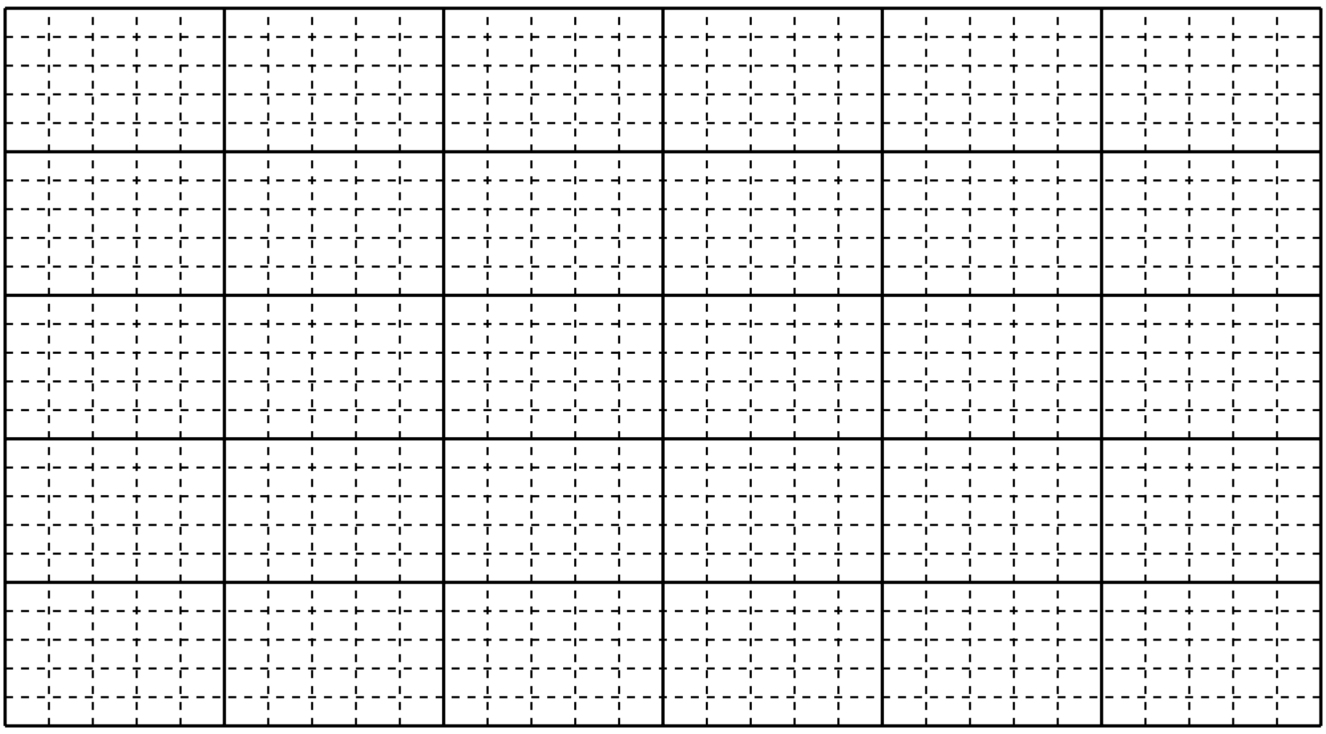
(c) Indicate below which quantities should be graphed to yield a straight line whose slope could be used to calculate a numerical value for the acceleration due to gravity g.

Horizontal axis: _____________

Vertical axis: _____________

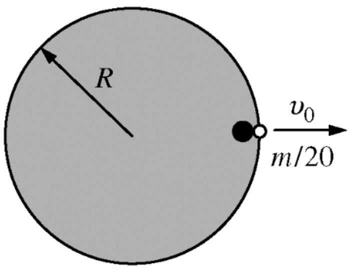
Use the remaining rows in the table above, as needed, to record any quantities that you indicated that are not given. Label each row you use and include units.

(d) Plot the straight line data points on the grid below. Clearly scale and label all axes, including units as appropriate. Draw a straight line that best represents the data.

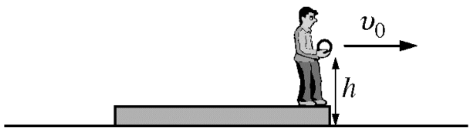


(e) i. Using your straight line, determine an experimental value for g.

ii. Describe two ways in which the effects of air resistance could be reduced.



Top View



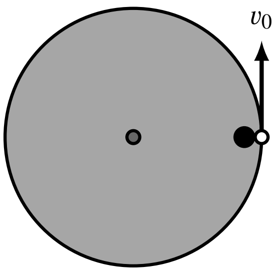
Side View

2. A large circular disk of mass m and radius R is initially stationary on a horizontal icy surface. A person of mass $m/2$ stands on the edge of the disk. Without slipping on the disk, the person throws a large stone of mass $m/20$ horizontally at initial speed v_0 from a height h above the ice in a radial direction, as shown in the figures above. The coefficient of friction between the disk and the ice is μ. All velocities are measured relative to the ground. The time it takes to throw the stone is negligible. Express all algebraic answers in terms of m, R, v_0, h, m, and fundamental constants, as appropriate.

   (a) Derive an expression for the length of time it will take the stone to strike the ice.

   (b) Assuming that the disk is free to slide on the ice, derive an expression for the speed of the disk and person immediately after the stone is thrown.

   (c) Derive an expression for the time it will take the disk to stop sliding.



Top View

The person now stands on a similar disk of mass m and radius R that has a fixed pole through its center so that it can only rotate on the ice. The person throws the same stone horizontally in a tangential direction at initial speed v_0, as shown in the figure above. The rotational inertia of the disk is $mR^2/2$.

   (d) Derive an expression for the angular speed ω of the disk immediately after the stone is thrown.

   (e) The person now stands on the disk at rest $R/2$ from the center of the disk. The person now throws the stone horizontally with a speed v_0 in the same direction as in part (d). Is the angular speed of the disk immediately after throwing the stone from this new position greater than, less than, or equal to the angular speed found in part (d)? Justify your answer.

   ____ Greater than   ____ Less than   ____ Equal to