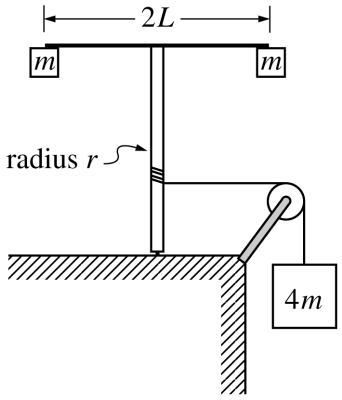


Experiment A

Mech 3.

A light string that is attached to a large block of mass $4m$ passes over a pulley with negligible rotational inertia and is wrapped around a vertical pole of radius r, as shown in Experiment A above. The system is released from rest, and as the block descends the string unwinds and the vertical pole with its attached apparatus rotates. The apparatus consists of a horizontal rod of length $2L$, with a small block of mass m attached at each end. The rotational inertia of the pole and the rod are negligible.

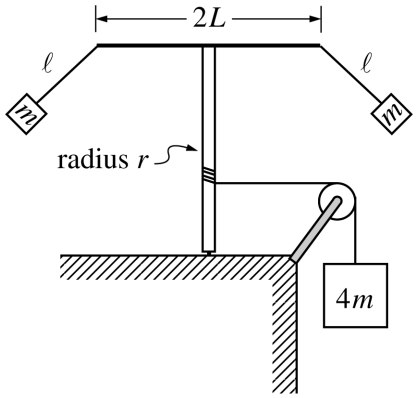
(a) Determine the rotational inertia of the rod-and-block apparatus attached to the top of the pole.

(b) Determine the downward acceleration of the large block.

(c) When the large block has descended a distance D, how does the instantaneous total kinetic energy of the three blocks compare with the value $4mgD$? Check the appropriate space below.

____ Greater than $4mgD$ ____ Equal to $4mgD$ ____ Less than $4mgD$

Justify your answer.



Experiment B

The system is now reset. The string is rewound around the pole to bring the large block back to its original location. The small blocks are detached from the rod and then suspended from each end of the rod, using strings of length ℓ. The system is again released from rest so that as the large block descends and the apparatus rotates, the small blocks swing outward, as shown in Experiment B above. This time the downward acceleration of the block decreases with time after the system is released.

(d) When the large block has descended a distance D, how does the instantaneous total kinetic energy of the three blocks compare to that in part (c) ? Check the appropriate space below.

____ Greater ____ Equal ____ Less

Justify your answer.

END OF SECTION II, MECHANICS

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Question 3

15 points total

3. (a) **3 points**

Distribution of Points

For a correct formula for the rotational inertia **1 point**

$I = \sum mr^2$

For a sum containing a term of the form mL^2 (may include extra incorrect terms, but the point was not awarded if the expression does not contain an mL^2 term) **1 point**

$I = mL^2 + mL^2$

For the correct answer **1 point**

$I = 2mL^2$

3. (b) **6 points**

For a correct expression of Newton's 2nd law **1 point**

$F = ma$

For correct substitutions into Newton's law **1 point**

$4mg - T = 4ma$

For a correct formula for torque **1 point**

$\tau = I\alpha$ or Tr

$I\alpha = Tr$

$T = \dfrac{I\alpha}{r}$

From Newton's 2nd law equation above:

$T = 4mg - 4ma$

Substituting into the torque equation:

$\dfrac{I\alpha}{r} = 4mg - 4ma$

For substituting the expression for *I* from part (a) into Newton's law **1 point**

$\dfrac{2mL^2\alpha}{r} = 4mg - 4ma$

For the expression $\alpha = a/r$ **1 point**

Substituting this expression into the previous equation:

$\dfrac{2mL^2 a}{r^2} = 4mg - 4ma$

For the correct answer **1 point**

$a = \dfrac{2gr^2}{L^2 + 2r^2}$

Note: For the solution $a = \dfrac{4mg - T}{4m}$, obtained by solving $4mg - T = 4ma$ for *a* directly, a maximum of **3 points** was awarded for part (b) as follows; **1 point** for Newton's law, **1 point** for substitutions, and **1 point** for answer.

Question 3 (cont.)

3. (c) **3 points**

Distribution of Points

For correctly checking the space in front of "Equal to 4*mgD*" **1 point**
For correct justification, such as "The kinetic energy gained by the two smaller blocks comes from the decrease in the potential energy of the 4*m* block." OR "Total energy is conserved." **2 points**

Note: **No points** awarded for part (c) if wrong box was checked.

3. (d) **3 points**

For correctly checking the space in front of "Less" **1 point**
For correct justification, such as "The small blocks rise and gain potential energy. The total energy available is still 4*mgD*. Therefore the kinetic energy must be less than in part (c)." **2 points**

Note: **No points** awarded for part (d) if wrong box was checked.