AP® Physics C: Mechanics
2001 Sample Student Responses

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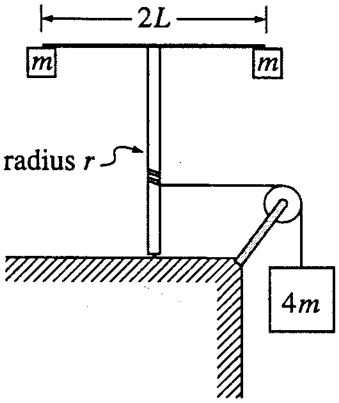


Experiment A

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.

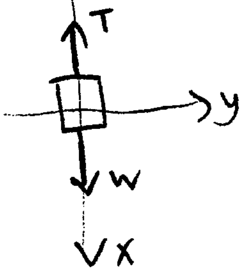
$$I = \sum m r^2$$

$$I = mL^2 + mL^2$$

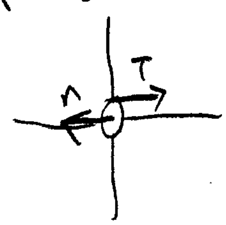
$$I = 2mL^2$$

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

large block



pole! (from above)



$$\sum F_x = \vec{w} + \vec{T} = 4ma$$

$$4mg - T = 4ma$$

$$\sum \tau = \tau_T = I\alpha$$

$$\vec{r} \times \vec{T} = 2mL^2 \frac{a}{r}$$

$$rT = 2mL^2 \frac{a}{r}$$

$$T = \frac{2mL^2 a}{r^2}$$

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

$$4mg = a\left(4m + \frac{2mL^2}{r^2}\right)$$

$$2g = a\left(2 + \frac{L^2}{r^2}\right)$$

$$\frac{2g}{2 + \frac{L^2}{R^2}} = a$$

(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.

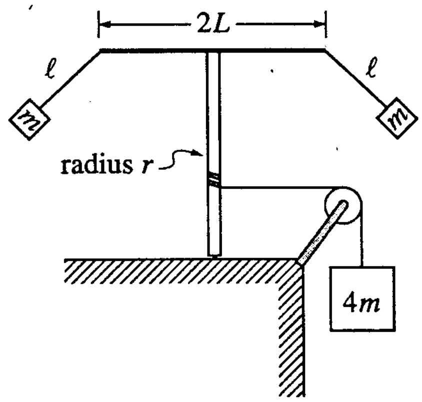
____ Greater than $4mgD$ __X__ Equal to $4mgD$ ____ Less than $4mgD$

Justify your answer.

Mechanical Energy is conserved, so

$$\Delta K = -\Delta U$$

$$K_{tot} = 4mgD$$



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 __X__ Less

Justify your answer.

Mechanical energy is still conserved, but some of that energy has gone into lifting the blocks on the rod (as potential energy), like this:

so the total kinetic energy is less than before.

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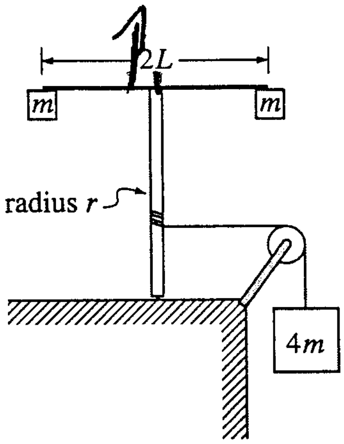


Experiment A

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.

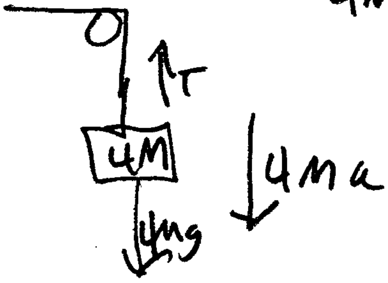
$I = Ml^2 + Ml^2$. Rod rotational inertia is negligible

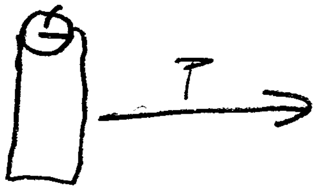
$\boxed{I = 2ml^2}$

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

$\Sigma F = 4ma$

$4Ma = 4mg - T$





$I\alpha = rT$

$I\frac{a}{r} = rT$

$\Sigma\Gamma = I\alpha$

$2ml^2\frac{a}{r} = rT$

$\frac{2ml^2 a}{r^2} = T$

$4\cancel{m}a = 4\cancel{m}g - \frac{2\cancel{m}l^2 a}{r^2}$

$4\cancel{m}a + \frac{2\cancel{m}l^2 a}{r^2} = 4\cancel{m}g$

$a(4\cancel{m} + \frac{2\cancel{m}l^2}{r^2}) = 4\cancel{m}g$

$a = \frac{4g}{4 + \frac{2l^2}{r^2}}$

$\boxed{a = \frac{g}{1 + \frac{l^2}{2r^2}}}$

GO ON TO THE NEXT PAGE.

(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 $4mgD$ X Equal to $4mgD$ ____ Less than $4mgD$

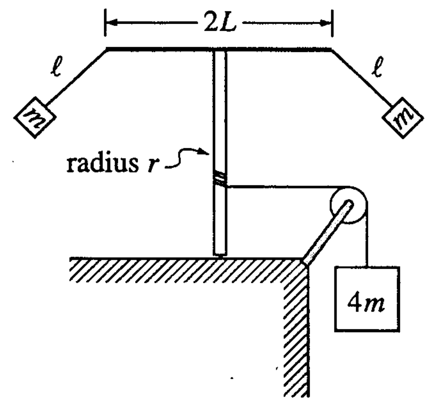
Justify your answer.

$\cancel{K_1} + U_{g_1} = K_2 + \cancel{U_{g_2}}$ ← no final potential energy in block

no initial K_1

$U_{g_1} = K_2$

$4mgd = \frac{1}{2}I\omega^2 + \frac{1}{2}mv^2$ so $4mgd$ = total KE



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 X Equal ____ Less

Justify your answer.

No energy is being lost. As the blocks swing out they simply increase the rotational inertia of the rod and blocks, this accounts for the decreasing acceleration. But no energy is lost to friction or other forces

$\cancel{K_1} + U_{g1} = K_2 + \cancel{U_{g2}}$ = no energy lost

Still $U_{g_1} = K_2$ = total KE is same,