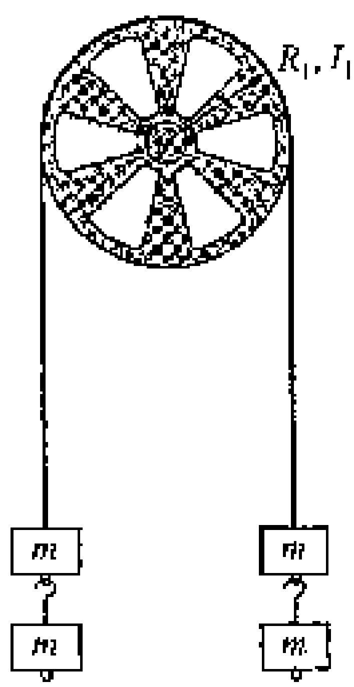
AP Physics C: Mechanics
2000 Student Samples

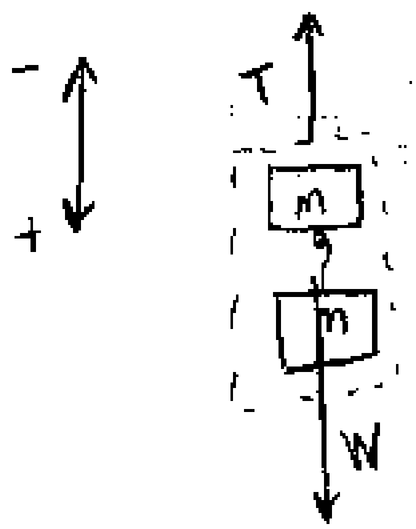
L1



Mech 3.

A pulley of radius R_1 and rotational inertia I_1 is mounted on an axle with negligible friction. A light cord passing over the pulley has two blocks of mass m attached to either end, as shown above. Assume that the cord does not slip on the pulley. Determine the answers to parts (a) and (b) in terms of m, R_1, I_1, and fundamental constants.

(a) Determine the tension T in the cord.

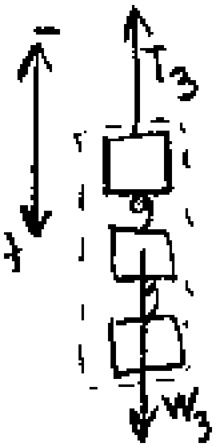


$\Sigma F = 0 = W - T$

$T = W = 2mg$

L2

(b) One block is now removed from the right and hung on the left. When the system is released from rest, the three blocks on the left accelerate downward with an acceleration $\frac{g}{3}$. Determine the following.

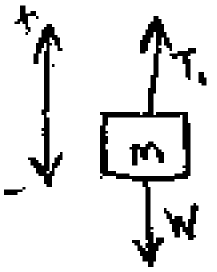


i. The tension T_3 in the section of cord supporting the three blocks on the left

$$\Sigma F = 3ma = W_3 - T_3$$

$$\frac{3mg}{3} = 3mg - T_3$$

$$T_3 = 3mg - \frac{mg}{3} = 2mg$$



ii. The tension T_1 in the section of cord supporting the single block on the right

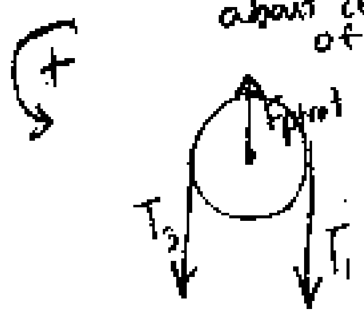
Acceleration along rope is equal at both ends

$$\Sigma F = ma = T_1 - W$$

$$T_1 = \frac{mg}{3} + mg = \frac{4}{3}mg$$

iii. The rotational inertia I_1 of the pulley

about center of disc



$$\Gamma_{net} = I_1\alpha = \Gamma_{T_3} - \Gamma_{T_1}$$

$$I_1 \frac{a}{R_1} = T_3 R_1 - T_1 R_1$$

$$\frac{I_1 a}{R_1} = 2mg R_1 - \frac{4}{3}mg R_1$$

$$\frac{I_1 \cancel{g}}{\cancel{3}R_1} = \frac{2}{\cancel{3}} m\cancel{g} R_1$$

$$I_1 = 2mR_1^2$$

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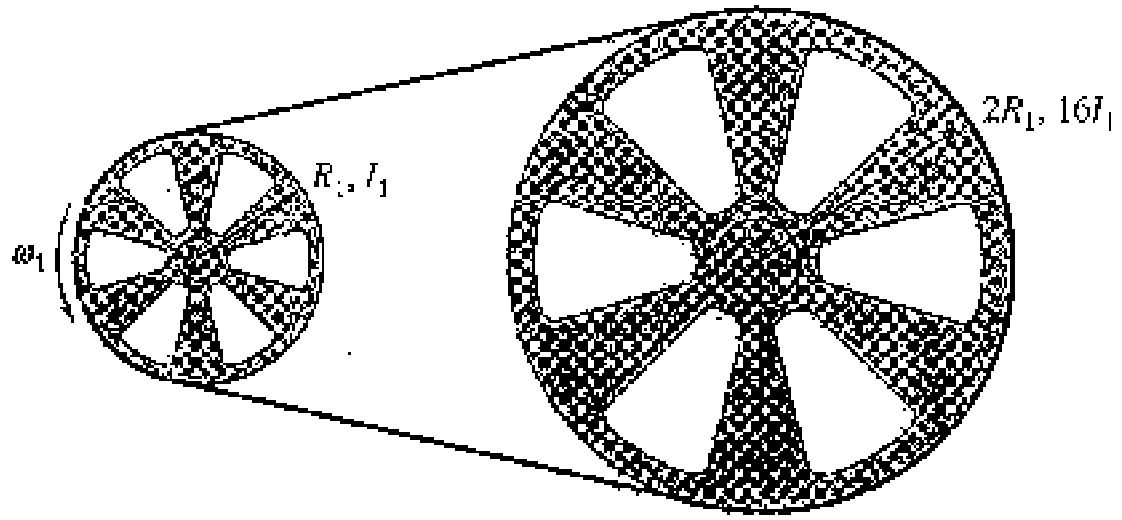
 L3



(c) The blocks are now removed and the cord is tied into a loop, which is passed around the original pulley and a second pulley of radius $2R_1$ and rotational inertia $16I_1$. The axis of the original pulley is attached to a motor that rotates it at angular speed ω_1, which in turn causes the larger pulley to rotate. The loop does not slip on the pulleys. Determine the following in terms of I_1, R_1, and ω_1.

i. The angular speed ω_2 of the larger pulley

$$\omega_1 = \frac{V_{cord}}{R_1}$$

$$V_{cord} = \omega_1 R_1$$

V_{cord} = constant

$$\omega_2 = \frac{V_{cord}}{R_2} = \frac{\omega_1 \cancel{R_1}}{2\cancel{R_1}} = \frac{\omega_1}{2}$$

ii. The angular momentum L_2 of the larger pulley

$$L_2 = I_2 \omega_2$$
$$= (16 I_1)\left(\frac{\omega_1}{2}\right)$$
$$= 8 I_1 \omega_1$$

iii. The total kinetic energy of the system

$$K_{tot} = K_{rot1} + K_{rot2}$$
$$= \frac{1}{2} I_1 \omega_1^2 + \frac{1}{2} I_2 \omega_2^2$$
$$= \frac{1}{2} I_1 \omega_1^2 + \frac{1}{2}(16 I_1)\left(\frac{\omega_1}{2}\right)^2$$
$$= \frac{1}{2} I_1 \omega_1^2 + 2 I_1 \omega_1^2$$
$$= \frac{5}{2} I_1 \omega_1^2$$

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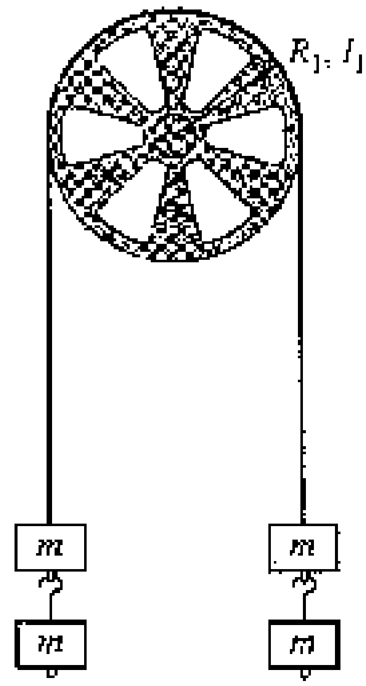
M1



Mech 3.

A pulley of radius R_1 and rotational inertia I_1 is mounted on an axle with negligible friction. A light cord passing over the pulley has two blocks of mass m attached to either end, as shown above. Assume that the cord does not slip on the pulley. Determine the answers to parts (a) and (b) in terms of m, R_1, I_1, and fundamental constants.

(a) Determine the tension T in the cord.

system in equilibrium
so $a=0$

$2mg - T = \cancel{2ma}$

$T - 2mg = \cancel{2ma}$

$T = 2mg$

GO ON TO THE NEXT PAGE.

(b) One block is now removed from the right and hung on the left. When the system is released from rest, the three blocks on the left accelerate downward with an acceleration $\frac{g}{3}$. Determine the following.

i. The tension T_3 in the section of cord supporting the three blocks on the left

$3mg - T_3 = 3ma$

$T_3 = 3mg - 3m\frac{g}{3}$

$I\alpha = R_1 T_3 - R_1 T$

$T_3 = 2mg$

$T_1 - mg = ma$

ii. The tension T_1 in the section of cord supporting the single block on the right

$T_1 - mg = ma_2$

$T_1 = m\frac{g}{3} + mg$

$T_1 = \frac{4}{3}mg$

iii. The rotational inertia I_1 of the pulley

$\alpha = \frac{a}{r}$

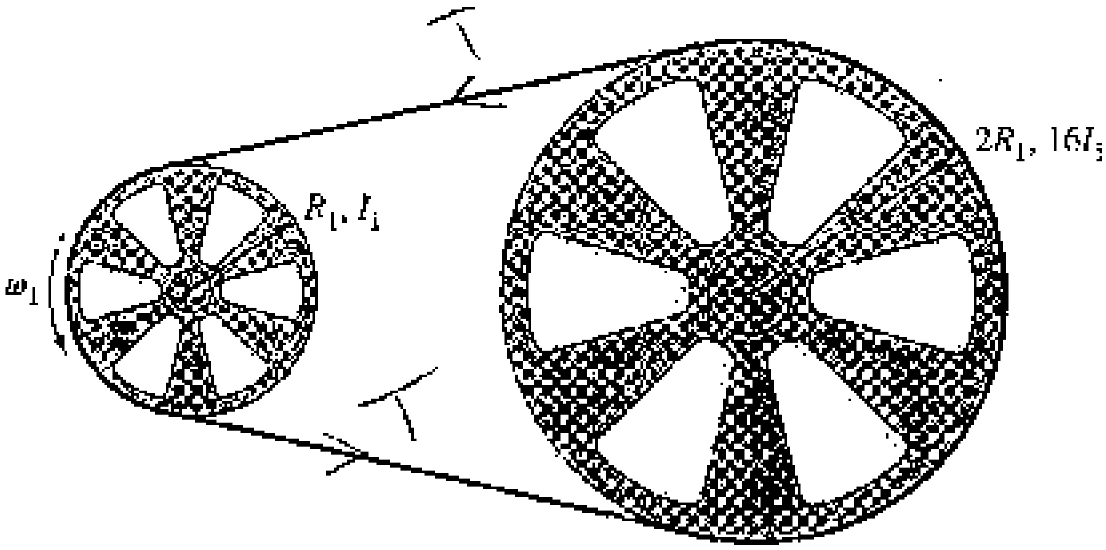
$I_1\left(\frac{g}{3R_1}\right) = R_1\left(2mg - \frac{4}{3}mg\right)$

$I_1\left(\frac{g}{3R_1}\right) = R_1\left(\frac{2}{3}mg\right)$

$I_1 = \frac{3R_1^2}{g}\left(\frac{2}{3}mg\right)$

$I_1 = 2mR_1^2$

M3



(c) The blocks are now removed and the cord is tied into a loop, which is passed around the original pulley and a second pulley of radius $2R_1$ and rotational inertia $16I_1$. The axis of the original pulley is attached to a motor that rotates it at angular speed ω_1, which in turn causes the larger pulley to rotate. The loop does not slip on the pulleys. Determine the following in terms of I_1, R_1, and ω_1.

i. The angular speed ω_2 of the larger pulley

ii. The angular momentum L_2 of the larger pulley

$L = I\omega$

iii. The total kinetic energy of the system

$KE = \cancel{\frac{1}{2}mv^2} + \frac{1}{2}I\omega^2$

$K = \frac{1}{2}I_1\omega_1^2 + \frac{1}{2}I_2\omega_2^2$

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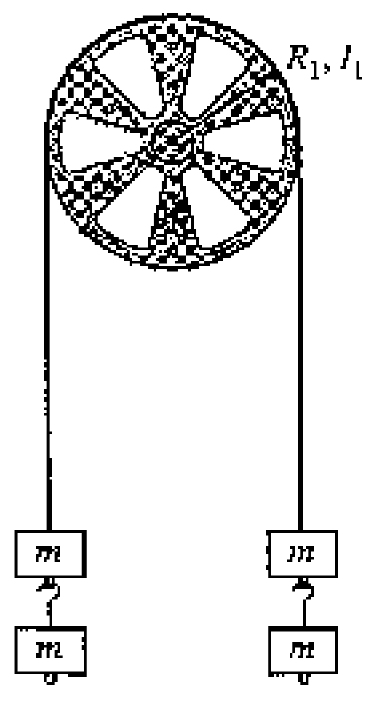
N1



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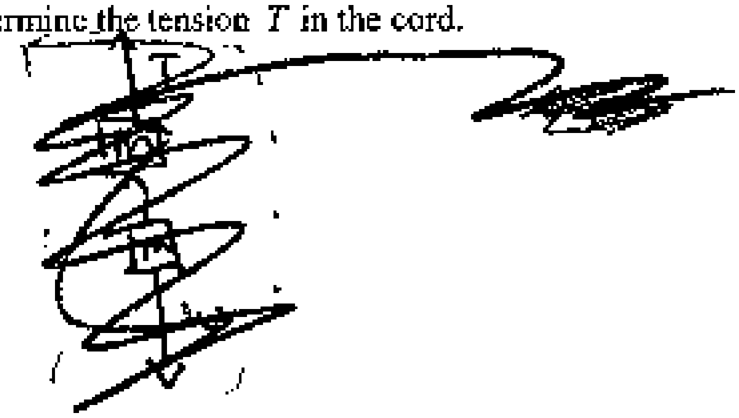
(a) Determine the tension T in the cord.



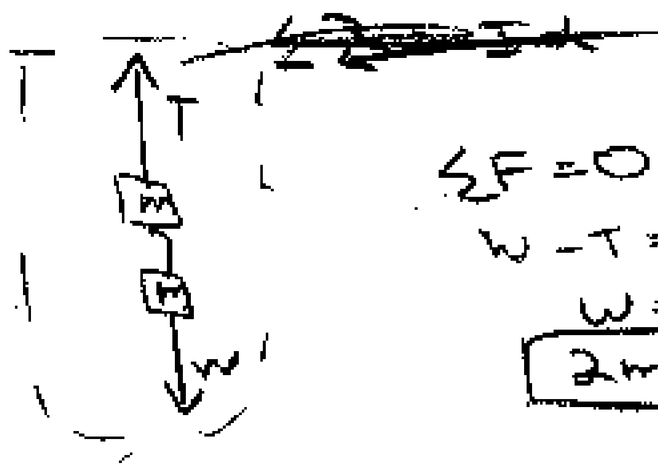
System $\Sigma F = ma$

$W_1 - W_2 = ma$

$2mg - 2mg = ma$

$0 = ma$

$a = 0$



$\Sigma F = 0$

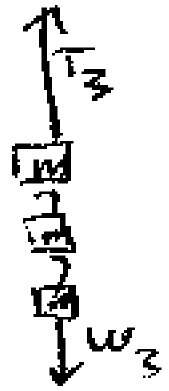
$W - T = 0$

$W = T$

$\boxed{2mg = T}$

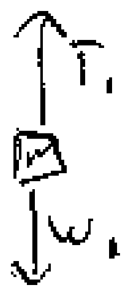
(b) One block is now removed from the right and hung on the left. When the system is released from rest, the three blocks on the left accelerate downward with an acceleration $\frac{g}{3}$. Determine the following.

i. The tension T_3 in the section of cord supporting the three blocks on the left



$$\Sigma F = ma$$
$$W_3 - T_3 = \frac{mg}{3}$$
$$3mg - T_3 = \frac{mg}{3}$$
$$3mg - \frac{mg}{3} = T_3$$
$$\frac{8}{3} mg = T_3$$

ii. The tension T_1 in the section of cord supporting the single block on the right



$$\Sigma F = ma$$
$$T_1 - W_1 = \frac{mg}{3}$$
$$T_1 = mg - \frac{mg}{3}$$
$$\boxed{T_1 = \frac{2}{3} mg}$$

iii. The rotational inertia I_1 of the pulley

$$\Sigma \tau = I\alpha$$
$$R_1 \times T_3 - R_1 \times T_1 = I\alpha$$
$$\frac{8}{3} R_1 mg - \frac{2}{3} R_1 mg = I\alpha$$
$$2R_1 mg = I\alpha$$
$$I = \frac{2R_1 mg}{\alpha}$$
$$= \frac{2R_1 mg}{\frac{g/3}{R_1}} = \frac{2R_1^2 mg}{\frac{g}{3}}$$
$$\boxed{I = 6R_1 m}$$

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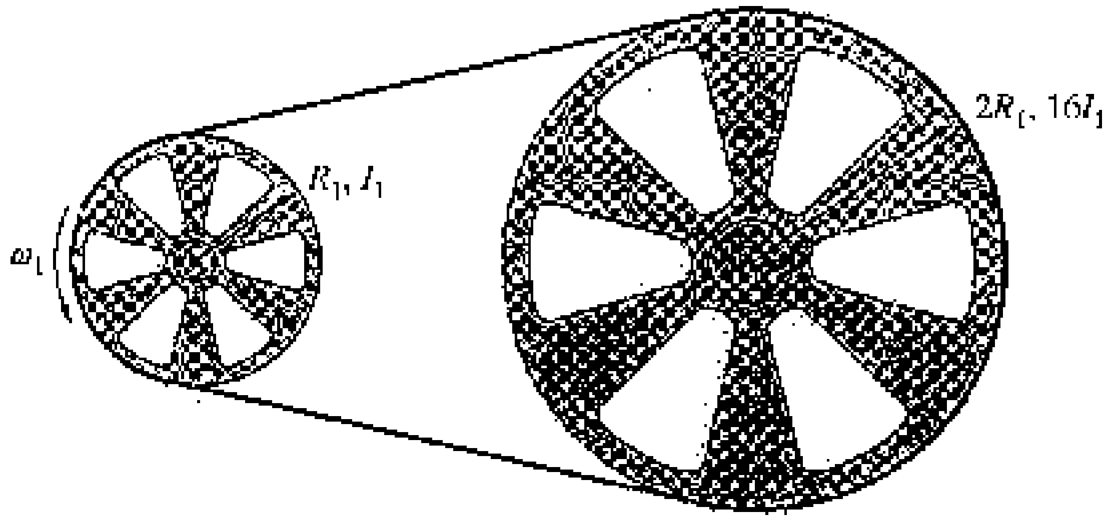

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