21-R-WE-ZA-46 Solution

Question: The motor M is attached to two blocks of mass $m_1\ kg$ and $m_2\ kg$ and applies a force of $F_M\ N$ to the cable. If $s_C\ m$ and $s_D\ m$, find the power required to move block 2 when $v_A\ m/s$ and $a_A\ m/s^2$.

Solution:

We start by writing relationships between each section of rope and differentiating.

(1): $s_A + 2r + s_B = l \Rightarrow v_A + 2v_r + v_B = 0 \Rightarrow a_A + 2a_r + a_B = 0$

(2): $r^2 = s_C^2 + s_D^2 \Rightarrow 2rv_r = 2s_Cv_C \Rightarrow v_r^2 + ra_r = v_C^2 + s_Ca_C$

Then we take the sum of forces about each block, as well as the pulley attached to block 1.

$\Sigma F_{x\,roller} = -F + 2T(s_C/r) = m_{roller}a_x \simeq 0$

$\Sigma F_{x\,1} = -F = m_1a_C$

$\Sigma F_{y\,2} = T - m_2g = m_2a_B$

As tension in the rope equals the force from the motor, we can substitute this in to find acceleration of block 2.

$T = F_M \Rightarrow a_B = (F_M - m_2g)/m_2$

Combining $\Sigma F_{x\,roller}$ and $\Sigma F_{x\,1}$ we can find the acceleration block 1.

$m_1a_C = -2Tx/r \Rightarrow a_C = -2F_Ms_C/(rm_1)$

Using equations 1 and 2, we can solve for the velocity of block C.

$a_A + 2a_r + a_B = 0 \Rightarrow a_A + 2(v_C^2 + s_Ca_C - (s_Cv_C/r)^2)/r + a_B = 0$

The velocity of block C and equations 1 and 2 gives us the velocity of block B. Then, we can find the power required to move block 2.

$v_B = -v_A - (2s_Cv_C/r)$

$P = F_Mv_B$