Quiz 14: Chapter 18

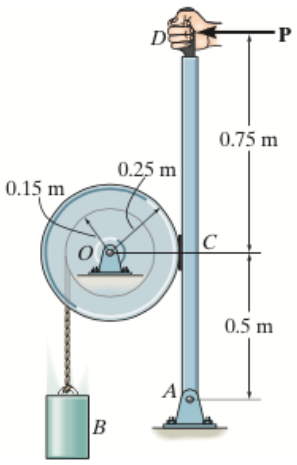
Due: Tuesday 26 March 2024

Examine the solved problem below. There are five errors. Your task is to locate and identify any mistakes, then correct them and calculate the proper result. If the same error occurs more than once, only count it as a single error, even if you have to correct it in more than one instance.

Each correctly identified error is worth 3 points, and the re-calculated results are worth 5 points. You must save your work in pdf format and submit via the Quiz 14 Assignment in the Chapter 18 folder of the in the Quizzes folder of the Online Classroom in Blackboard. Please do not use any other file format than pdf.

The drum has a mass $m = 40\text{kg}$ and a radius of gyration about the pin at O of $k_O = 0.20\text{m}$. The suspended block B has a mass $m_B = 10\text{kg}$. It is released from rest and allowed to fall $y_1 = 2.5\text{m}$ without applying the brake ACD. Determine the speed v_B of the block at this instant.

If the coefficient of kinetic friction at the brake pad C is $\mu_k = 0.45$, determine the force P that must be applied at the brake handle which will then stop the block after it descends another $y_2 = 2.5\text{m}$. Neglect the thickness of the handle.



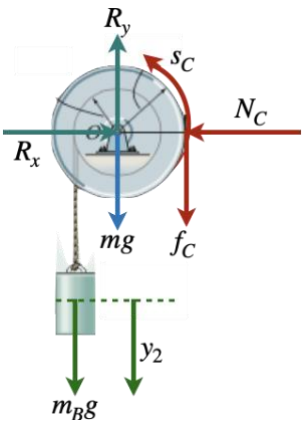
A) Conserve the energy of the drum + block system over the first $y_1 = 2.5\text{m}$ displacement:

$$T_0 + V_0 = T_1 + V_1$$
$$0 + 0 = \tfrac{1}{2}m_B v_B^2 + \tfrac{1}{2}I_O\omega_1^2 - m_B g y_1$$
$$\tfrac{1}{2}m_B r_o^2\omega_1^2 + \tfrac{1}{2}\left(\tfrac{1}{2}mk_O^2\right)\omega_1^2 = m_B g y_1$$
$$\left(\tfrac{1}{2}m_B r_o^2 + \tfrac{1}{4}mk_O^2\right)\omega_1^2 = m_B g y_1$$

$$\left[\tfrac{1}{2}(10\text{kg})(0.25\text{m})^2 + \tfrac{1}{4}(40\text{kg})(0.20\text{m})^2\right]\omega_1^2 = (10\text{kg})\left(9.8\tfrac{\text{m}}{\text{s}^2}\right)(2.5\text{m})$$
$$\omega_1 = 8.68\tfrac{\text{rad}}{\text{s}}$$
$$v_B = \omega_1 r_o = \left(8.68\tfrac{\text{rad}}{\text{s}}\right)(0.25\text{m}) = 2.17\tfrac{\text{m}}{\text{s}}$$

B) Construct the free-body diagram for the drum + block system:
See diagram on the right; y_2 is vertical drop of block B and s_C is length of arc through which drum rotates as the lever is applied and the drum slows to a stop.

$$y_2 = r_i\theta \qquad s_C = (0.25\text{m})(0.15\text{m})(2.5\text{m})$$
$$s_C = r_o\theta = r_o r_i y_2 \qquad s_C = 0.625\text{m}$$



C) Use work-energy to calculate the frictional force f_c on the drum:

$$T_1 + U_{1\to 2} = T_2$$
$$m_B g y_1 + [m_B g y_2 - f_C s_C] = 0$$
$$f_C = \frac{m_B g y_1 + m_B g y_2}{s_C}$$

$$f_C = \frac{(10\text{kg})\left(9.8\tfrac{\text{m}}{\text{s}^2}\right)(2.5\text{m} + 2.5\text{m})}{0.625\text{m}}$$
$$f_C = 784\text{N}$$

D) Construct the free-body diagram for the brake lever:
See diagram on the right.

E) Solve the static equilibrium of the brake lever for the applied force P:

$$\sum M_A = Pr_{AD} - N_C r_{AC} = 0$$
$$P = \left(\frac{r_{AC}}{r_{AD}}\right)N = \left(\frac{r_{AC}}{r_{AD}}\right)\frac{f_C}{\mu_k}$$

$$P = \left(\frac{0.5\text{m}}{1.25\text{m}}\right)\frac{784\text{N}}{0.45}$$
$$P = 697\text{N}$$