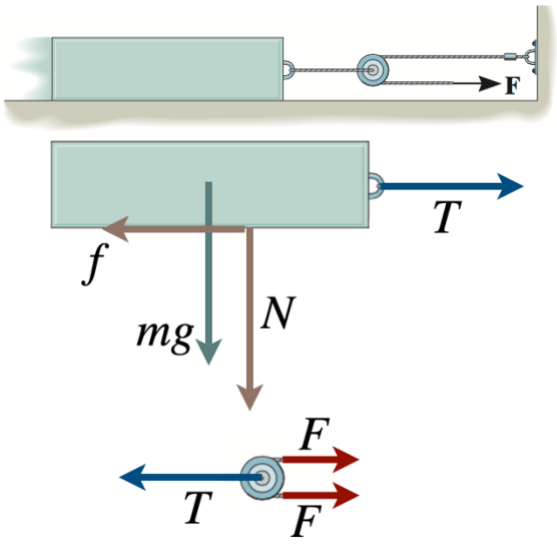
Quiz 05: Chapter 14

Due: Friday 09 Feb 24

Examine the solved problem below. There are four errors in the solution below. Your task is to locate and identify those errors, 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 4 points, and the re-calculated result is worth 4 points as well. You must save your work in pdf format and submit via the Quiz 05 Assignment in the Chapter 14 folder in the Quizzes folder of the Online Classroom in Blackboard. Please do not use any other file format than pdf.

The block shown has a mass $m = 150\text{kg}$ and rests on a surface for which the coefficients of static and kinetic friction are $\mu_s = 0.5$ and $\mu_k = 0.4$, respectively. A force $F = (60t^2)\text{N}$, where t is in seconds, is applied to the cable. Neglect the mass of the pulley. Determine the time needed for the force to cause motion and the power developed by the force F when $t = 5\text{s}$.



A) Sketch the free body diagrams for the block and the pulley.

See diagrams on the right. Before the block starts moving, $f = f_s = \mu_s N$, and when the block is in motion $f = f_k = \mu_k N$.

B) Write the equilibrium equations for block at rest:

$$\sum F_x = T - f_s = 0 \qquad T = f_s = \mu_s N$$
$$\sum F_y = N - mg = 0 \qquad N = mg$$

C) Write the equilibrium equation for the pulley at rest:

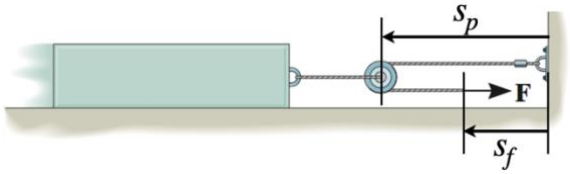
$$\sum F_x = 2F - T = 0$$
$$T = 2F = 2(60t^2) = 120t^2$$

D) Combine equations and solve for the time:

$$120t^2 = \mu_s(mg)$$
$$t = \frac{\sqrt{\mu_s mg}}{120} \qquad t = \frac{\sqrt{(0.4)(150\text{kg})\left(9.8\frac{\text{m}}{\text{s}^2}\right)}}{120} = 0.202\text{s}$$

E) Rewrite the equation for the block in motion:

$$\sum F_x = T - f_k = ma$$
$$120t^2 - \mu_k(mg) = ma$$



F) Calculate velocity of the block by integrating: $v_b = \int a dt$:

$$v_b = \int_0^{5\text{s}} \left[\frac{120t^2 - \mu_k(mg)}{m}\right] dt = \left(\frac{40t^3}{m} - \mu_k g t\right)\Big|_0^5$$
$$v_b = \frac{40(5)^3}{(150)} - (0.5)(9.8)(5) = 8.83\frac{\text{m}}{\text{s}}$$

G) Write the dependent motion equation to calculate velocity of the point of application of the force:

$$l = s_p + (s_p - s_f) = 2s_p - s_f \qquad 2v_p = v_f$$
$$\dot{l} = 2\dot{s}_p - \dot{s}_f = 0 \qquad v_p = v_b$$
$$v_f = 2v_b = \tfrac{1}{2}\left(8.83\tfrac{\text{m}}{\text{s}}\right) = 17.7\tfrac{\text{m}}{\text{s}}$$

H) Calculate the power developed by the force at its point of application:

$$P = F \cdot v_f = (60t^2)v_f = 60(5)^2\left(17.7\tfrac{\text{m}}{\text{s}}\right) = 26.5\text{kW}$$