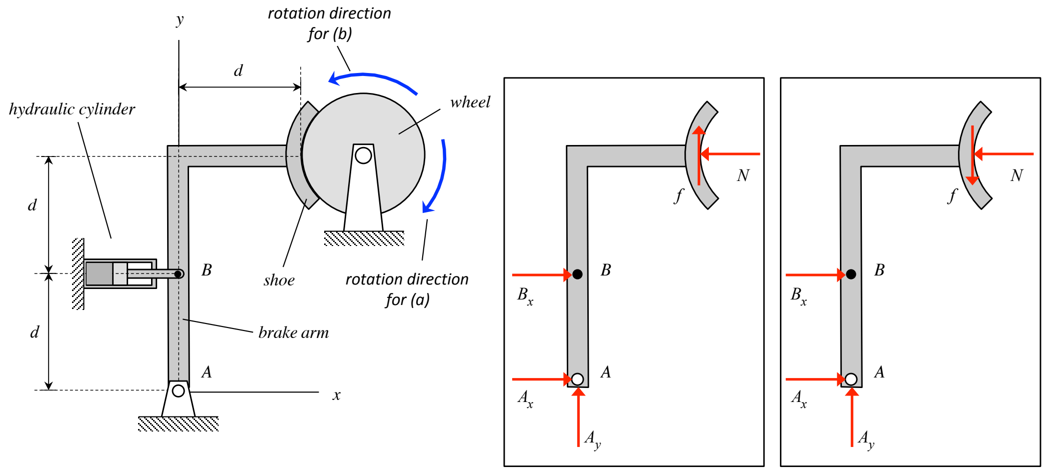
Example 6.B.8 - Solved

Given: The hydraulic cylinder exerts a force to the right on a brake arm at point B. This action brings the brake shoe into contact with a rotating wheel in order to eventually bring the wheel to a stop through friction. The coefficient of kinetic friction between the brake shoe and the wheel is μ_k = 0.5. Please note that although the wheel is decelerating during braking, the arm is in equilibrium. Consider the weight of the arm and a shoe to be negligible as compared to the hydraulic force.

Find: Find the ratio of the normal force between the brake shoe and wheel to the hydraulic cylinder force:
(a) For the wheel rotating *clockwise.*
(b) For the wheel rotating *counterclockwise.*
(c) For which wheel rotation direction (clockwise or counterclockwise) is the braking system more efficient?



FBD (a) FBD (b)

Part (a)
With the wheel turning in the *CW* direction, the friction force on the brake arm points *upward*. Using the FBD for the arm:

$$\sum M_A = -B_x(d) + N(2d) + f(d) = 0$$

Since the wheel slips on the wheel: $f = \mu_k N$.

Therefore:

$$(2+\mu_k)N = B_x \quad \Rightarrow \quad \frac{N}{B_x} = \frac{1}{2+\mu_k} = \frac{10}{25}$$

Part (b)
With the wheel turning in the *CCW* direction, the friction force on the brake arm points *downward*. Using the FBD for the arm:

$$\sum M_A = -B_x(d) + N(2d) - f(d) = 0$$

Since the wheel slips on the wheel: $f = \mu_k N$.

Therefore:

$$(2-\mu_k)N = B_x \quad \Rightarrow \quad \frac{N}{B_x} = \frac{1}{2-\mu_k} = \frac{10}{15}$$

Note that the braking system generates a higher normal force for CCW wheel rotation (Part (b)) than for CW wheel rotation (Part (a)). Therefore, the braking is more efficient for CCW (more friction force for the same piston force B_x).