<8.3~8.4절>

8.9 $P = 10\ \text{N}$, $W = 15\ \text{N}$, $\mu_s = 0.40$, $\mu_k = 0.35$

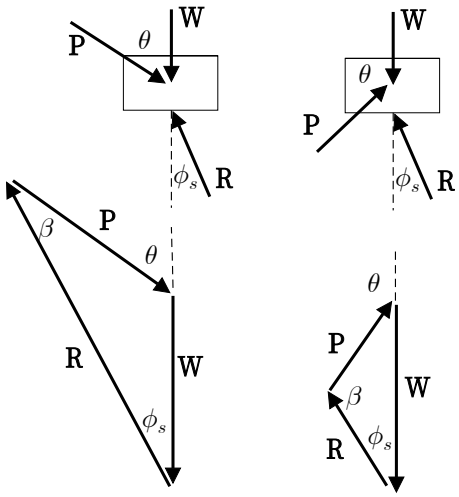
<방법1 : 힘 삼각형>

정지마찰각 $\phi_s = \tan^{-1}\mu_s = \tan^{-1}(0.40) = 21.8°$

$$\frac{\sin\beta}{W} = \frac{\sin\phi_s}{P}$$

$$\sin\beta = \frac{W}{P}\sin\phi_s = \frac{15\ \text{N}}{10\ \text{N}}\sin 21.8° = 0.557$$

$\beta = \sin^{-1}(0.557) = 33.9°$ 또는 $146.1°$



(a) $\beta = 33.9°$ 일 때

$\theta = \beta + \phi_s = 33.9° + 21.8° = 55.7°$

평형상태이기 위하여 $0 \le \theta \le 55.7°$

(b) $\beta = 146.1°$ 일 때

$\theta = \beta + \phi_s = 146.1° + 21.8° = 167.9°$

평형상태이기 위하여 $167.9° \le \theta \le 180°$

<방법2 : 직각성분 평형식>

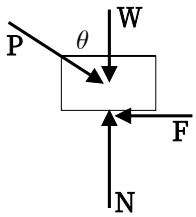
$F \le \mu_s N$

$\rightarrow \Sigma F_x = 0$; $P\sin\theta - F = 0$

$\Rightarrow \quad P\sin\theta \le \mu_s N \qquad \cdots ①$

$\uparrow \Sigma F_y = 0$; $N - W - P\cos\theta = 0$

$\Rightarrow \quad N = W + P\cos\theta \qquad \cdots ②$



②를 ①에 대입

$P\sin\theta \le \mu_s (W + P\cos\theta)$

$P^2\sin^2\theta = P^2(1 - \cos^2\theta) \le \mu_s^2 (W^2 + 2WP\cos\theta + P^2\cos^2\theta)$

$\Rightarrow \quad (1+\mu_s^2)P^2\cos^2\theta + 2\mu_s^2 WP\cos\theta + (\mu_s^2 W^2 - P^2) \ge 0$

$$\Rightarrow \quad \cos\theta_s = \frac{-\mu_s^2 WP \pm \sqrt{\mu_s^4 W^2 P^2 - (1+\mu_s^2)P^2(\mu_s^2 W^2 - P^2)}}{(1+\mu_s^2)P^2}$$

$$= \frac{-\mu_s^2 W \pm \sqrt{\mu_s^4 W^2 - (1+\mu_s^2)(\mu_s^2 W^2 - P^2)}}{(1+\mu_s^2)P}$$

$$= \frac{-(0.4)^2(15\ \text{N}) \pm \sqrt{(0.4)^4(15\ \text{N})^2 - (1+0.4^2)[(0.4)^2(15\ \text{N})^2 - (10\ \text{N})^2]}}{[1+(0.4)^2](10\ \text{N})}$$

$= 0.5642, \quad -0.9780$

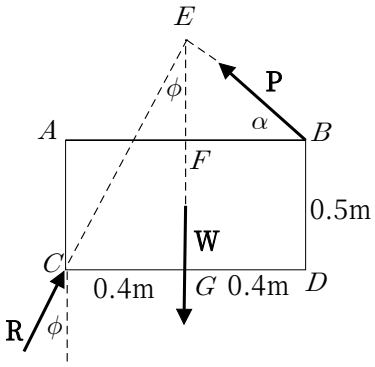
$\Rightarrow \quad \theta_s = \cos^{-1}(0.5642) = 55.7°$

$\theta_s = \cos^{-1}(-0.9780) = 167.9°$

(a) $\cos\theta \ge 0.5642 \quad \Rightarrow \quad 0 \le \theta \le 55.7°$

(b) $\cos\theta \le -0.9780 \quad \Rightarrow \quad 167.9° \le \theta \le 180°$

8.15 $\mu_s = 0.35$, $W = (40\ \text{kg})(9.81\ \text{m/s}^2) = 392.4\ \text{N}$



<방법1 : 힘 삼각형>

$\phi_s = \tan^{-1}\mu_s = \tan^{-1}(0.35) = 19.3°$

(a) $\tan\phi = \dfrac{CG}{EG}$

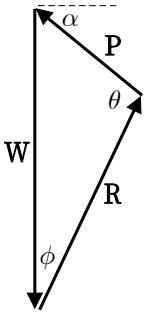
$\Rightarrow \quad EG = \dfrac{CG}{\tan\phi} = \dfrac{0.4\ \text{m}}{0.35} = 1.143\ \text{m}$

$EF = EG - FG$

$= (1.143\ \text{m}) - (0.5\ \text{m}) = 0.643\ \text{m}$

$\tan\alpha_s = \dfrac{EF}{FB} = \dfrac{0.643\ \text{m}}{0.4\ \text{m}} = 1.6075$

$\alpha_s = \tan^{-1}(1.6075) = 58.1°$



(b) $180° - \theta = \phi_s + (90° - \alpha_s)$

$= 19.3° + (90° - 58.1°) = 51.2°$

$\theta = 180° - 51.2° = 128.8°$

$\dfrac{\sin\phi_s}{P} = \dfrac{\sin\theta}{W}$

$\Rightarrow \quad P = W\dfrac{\sin\phi_s}{\sin\theta} = (392.4\ \text{N})\ \dfrac{\sin 19.3°}{\sin 128.8°} = 166.4\ \text{N}$

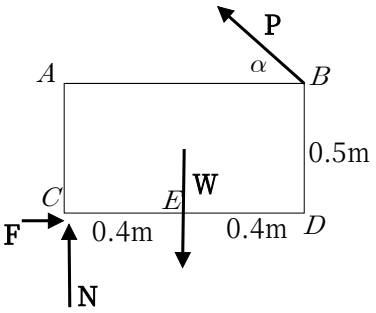
<방법2 : 직각성분 평형식>

$F = \mu_s N$

$\rightarrow \Sigma F_x = 0$;

$F - P\cos\alpha = 0$

$\Rightarrow \quad P\cos\alpha = \mu_s N \qquad \cdots ①$



$\uparrow \Sigma F_y = 0$;

$N - W + P\sin\alpha = 0$

$\Rightarrow \quad P\sin\alpha = -N + W \qquad \cdots ②$

$\circlearrowleft \Sigma M_C = 0$;

$(CA)\ P\cos\alpha + (CD)\ P\sin\alpha - (CE)\ W = 0$

$\Rightarrow \quad (CA)\ \mu_s N + (CD)\ (-N + W) - (CE)\ W = 0$

$\Rightarrow \quad N = \dfrac{(CD) - (CE)}{(CD) - \mu_s(CA)}\ W = \dfrac{(0.8\ \text{m}) - (0.4\ \text{m})}{(0.8\ \text{m}) - 0.35\,(0.5\ \text{m})}\ (392.4\ \text{N}) = 251.1\ \text{N}$

① $\Rightarrow \quad P\cos\alpha = (0.35)(251.1\ \text{N}) = 87.90\ \text{N} \qquad \cdots ③$

② $\Rightarrow \quad P\sin\alpha = -(251.1\ \text{N}) + (392.4\ \text{N}) = 141.3\ \text{N} \qquad \cdots ④$

(a) ④÷③ ; $\tan\alpha = \dfrac{141.3\ \text{N}}{87.9\ \text{N}} = 1.6075 \quad \Rightarrow \quad \alpha_s = \tan^{-1}(1.6075) = 58.1°$

(b) ③^2+④^2 ; $P = \sqrt{(87.9\ \text{N})^2 + (141.3\ \text{N})^2} = 166.4\ \text{N}$