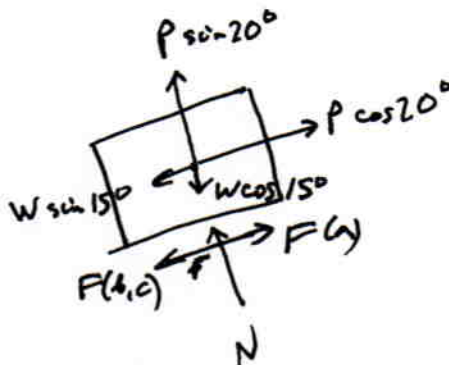
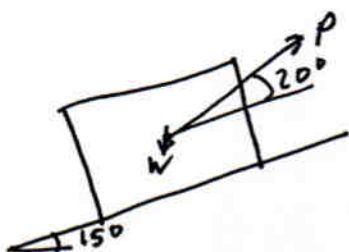


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$W = 981 \text{ N}; \mu_s = 0.30; \mu_k = 0.20$

(a)  $P = 200 \text{ N}$ :

$F = W \sin 15^\circ - P \cos 20^\circ = \underline{66 \text{ N}}$   
 $N = W \cos 15^\circ - P \sin 20^\circ = 879 \text{ N}$

$\mu_s N = 264 \text{ N} > F \quad \text{OK}$

(b)

$F = \mu_s N = 0.30 (W \cos 15^\circ - P \sin 20^\circ)$   
 $= P \cos 20^\circ - W \sin 15^\circ$

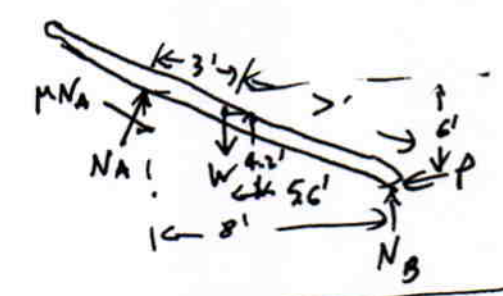
$\underline{P} = \frac{0.30 \cos 15^\circ + \sin 15^\circ}{\cos 20^\circ + 0.30 \sin 20^\circ} = \underline{516 \text{ N}}$

(c)  $P = 600 \text{ N} > 516 \text{ N} \Rightarrow \text{motion} \Rightarrow F = \mu_k N$

$N = W \cos 15^\circ - P \sin 20^\circ = 742 \text{ N}$

$\underline{F} = 0.20 \times 742 \text{ N} = \underline{148.5 \text{ N}}$

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$\mu = \mu_s = 0.40$

$\sum M_B = 0: 10 N_A - 5.6 W = 0$

$\Rightarrow N_A = \frac{5.6}{10} \cdot 150 \text{ lb} = 84 \text{ lb}$

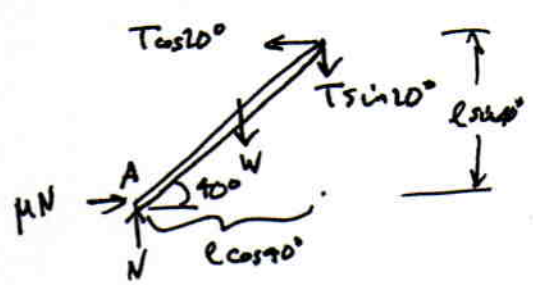
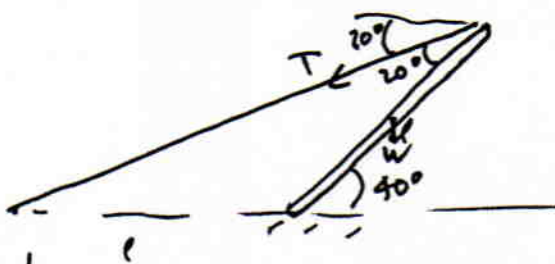
$\sum F_y = 0: N_B + (0.8 - 0.6\mu) N_A = W$

$\Rightarrow N_B = 150 \text{ lb} - (0.8 - 0.6 \times 0.4) \cdot 84 \text{ lb} = 103.0 \text{ lb}$

$\sum F_x = 0: P = \mu N_B + (0.6 + 0.8\mu) N_A \Rightarrow \underline{P = 118.5 \text{ lb}}$

$\sum M_x = 0 \text{ (check)}: 6P + 2.4W - 8N_B - 6\mu N_B \Rightarrow P = 118.5 \text{ lb}$

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Algebraic sol.

$$\sum M_A = 0: T \underbrace{(\cos 20^\circ \sin 40^\circ - \sin 20^\circ \cos 40^\circ)}_{\sin 20^\circ} l - W \frac{l}{2} \cos 40^\circ = 0$$

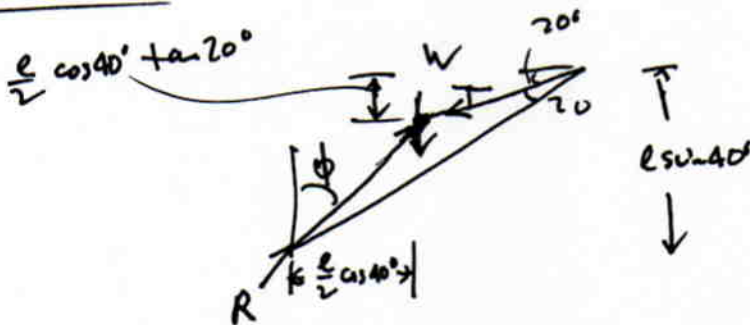
$$\Rightarrow T = \frac{\cos 40^\circ}{2 \sin 20^\circ} W$$

$$\sum F_y = 0: N = W + T \sin 20^\circ = \left(1 + \frac{1}{2} \cos 40^\circ\right) W$$

$$\sum F_x = 0: MN = T \cos 20^\circ = \frac{\cos 40^\circ}{2 \tan 20^\circ} W$$

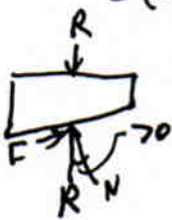
$$\mu = \frac{\cos 40^\circ}{\tan 20^\circ (2 + \cos 40^\circ)} = \underline{0.761}$$

Graphic sol.



$$\mu = \tan \phi = \frac{\frac{l}{2} \cos 40^\circ}{l (\sin 40^\circ - \frac{1}{2} \cos 40^\circ \tan 20^\circ)} = \frac{1}{2 \tan 40^\circ - \tan 20^\circ} = \underline{0.761}$$

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$$7^\circ \leq \phi \Rightarrow \mu = \tan \phi \geq \tan 7^\circ = 0.1228$$

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$$r = 8 \text{ mm}, L = 4 \text{ mm} \Rightarrow \alpha = \tan^{-1}(4/16\pi) = 4.55^\circ; \phi = \tan^{-1} 0.24 = 13.5^\circ$$

$$W = T = 8 \text{ kN}$$

$$M_{\text{winding}} = W r \tan(\alpha + \phi) = 20.86 \text{ N}\cdot\text{m}$$

$$M_{\text{unwinding}} = W r \tan(\phi - \alpha) = 10.08 \text{ N}\cdot\text{m}$$

$$\underline{M} = M_{\text{winding}} + M_{\text{unwinding}} = \underline{30.9 \text{ N}\cdot\text{m}}$$