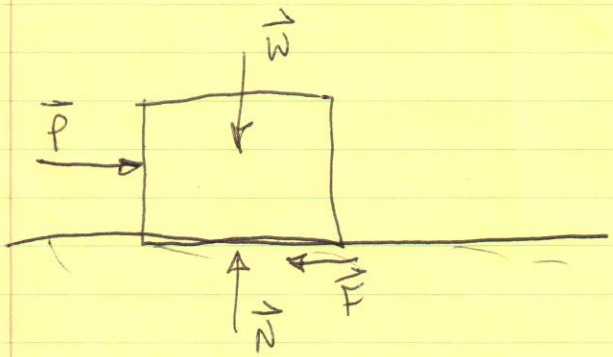
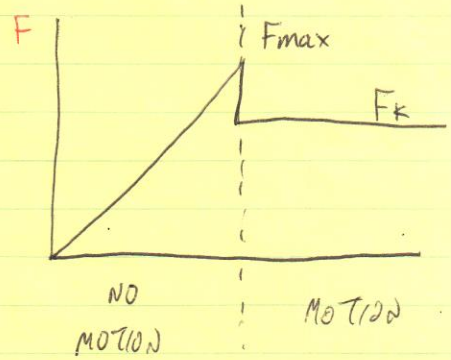
# CHAPTER 8: FRICTION

FRICTION FORCES OPPOSE MOTION.




$F_{max} = \mu_s N$ COEFFICIENT OF STATIC FRICTION

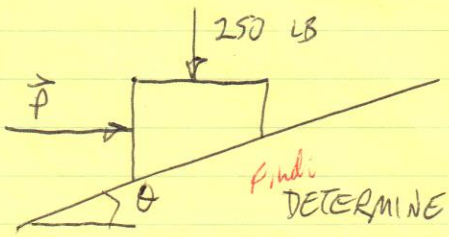
$F_K = \mu_K N$ COEFFICIENT OF KINETIC FRICTION

NO MOTION WILL OCCUR IF $\vec{F} < \vec{F}_{max} = \mu_s N$

MOTION WILL OCCUR IF $\vec{F} > \vec{F}_{max}$. AT THIS POINT, $\vec{F} = \mu_K N$

IF MOTION IS IMPENDING, $\vec{F} = \vec{F}_{max} = \mu_s N$

## EXAMPLE PROB. 8.1




Given: Schematic

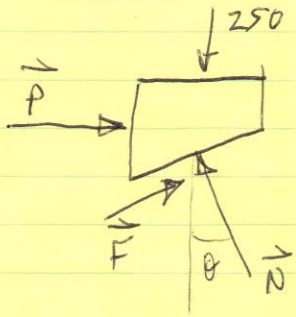
$\mu_s = 0.3$, $\mu_K = 0.2$

$\theta = 30°$, $P = 50$ LB

Find: DETERMINE IF BLOCK IS IN EQUILIBRIUM, MAGNITUDE & DIRECTION OF FRICTION FORCE.

PROB. 8.1 CONT.

FBD




ASSUME BLOCK IS IN EQUILIBRIUM.

$\vec{F} = (F\cos 30^\circ)\,\hat{i} + (F\sin 30^\circ)\,\hat{j}$ LB

$\vec{N} = (-N\sin 30^\circ)\,\hat{i} + (N\cos 30^\circ)\,\hat{j}$ LB

$\Sigma F_x = 0: \quad P + F\cos 30 - N\sin 30 = 0$

$0.866F - 0.5N = -50$

$\Sigma F_y = 0: \quad -250 + F\sin 30 + N\cos 30 = 0$

$0.5F + 0.866N = 250$

$N = 241.5$ LB, $\quad F = 81.7$ LB

MAXIMUM FRICTION FORCE:

$F_{max} = \mu_s N = (0.3)(241.5\ \text{LB}) = 72.4$ LB

SINCE $F > F_{max}$, BLOCK WILL SLIDE DOWN

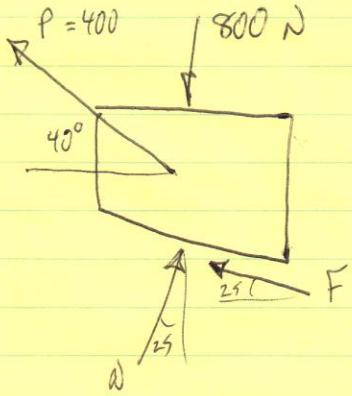
FRICTION FORCE:

$F = \mu_k N = (0.2)(241.5\ \text{LB}) = 48.3$ LB

FRICTION FORCE IS DIRECTED UP THE PLANE BECAUSE IT OPPOSES MOTION

PROB. 8.3

FBD:




ASSUME EQUILIBRIUM

$\vec{P} = (-P\cos 40^\circ)\hat{i} + (P\sin 40^\circ)\hat{j}$

$\vec{F} = (-F\cos 25^\circ)\hat{i} + (F\sin 25^\circ)\hat{j}$

$\vec{N} = (N\sin 25^\circ)\hat{i} + (N\cos 25^\circ)\hat{j}$

$\Sigma F_x = 0: \quad -400\cos 40^\circ + N\sin 25^\circ - F\cos 25^\circ = 0$

$0.423N - 0.906F = 306$

$\Sigma F_y = 0: \quad 400\sin 40^\circ - 800 + N\cos 25^\circ + F\sin 25^\circ = 0$

$0.906N + 0.423F = 543$

$F = -48.0 \text{ [N]}, \quad N = 622 \text{ [N]}$

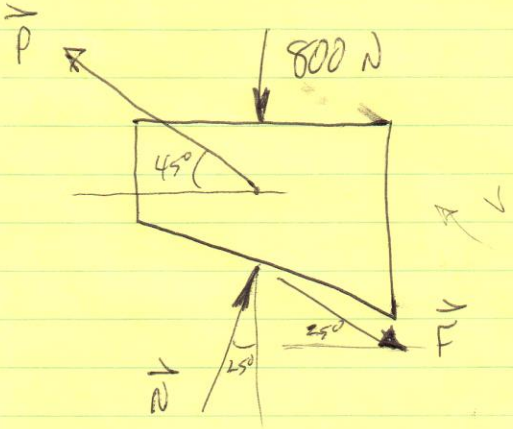
MAXIMUM FRICTION FORCE IS

$F_{max} = \mu_s N = (0.2)(622N) = 124 \text{ [N]}$

SINCE $F < F_{max}$, BLOCK IS IN EQUILIBRIUM.

EXAMPLE PROB. 8.5

FBD: IMPENDING MOTION UP THE RAMP.




$\Sigma F_x = 0$: $-P\cos 45^\circ + N\sin 25^\circ + F\cos 25^\circ = 0$

$F = F_{max} = \mu_s N = 0.2N$

$-0.707P + 0.423N + (0.2N)(0.906) = 0$

$P = 0.854N$

$\Sigma F_y = 0$: $P\sin 45^\circ + N\cos 25^\circ - F\sin 25^\circ - 800 = 0$

$0.707P + 0.906N - (0.2N)(0.423) - 800 = 0$

$0.707P + 0.821N = 800$

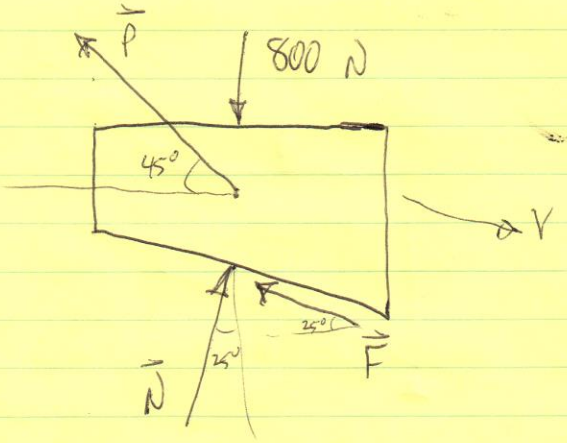
$0.707(0.854N) + 0.821N = 800$

$N = 561\ N$

$P = 0.854(561N) = 479\ N$

8.5

FBD: IMPENDING MOTION DOWN THE RAMP:




$\Sigma F_x = 0$: $-P\cos 45^\circ + N\sin 25^\circ - F\cos 25^\circ = 0$

$-0.707P + 0.423N - (0.2N)(0.906) = 0$

$P = 0.342N$

$\Sigma F_y = 0$: $P\sin 45^\circ + N\cos 25^\circ + F\sin 25^\circ - 800 = 0$

$0.707P + 0.906N + (0.2N)(0.423) = 800$

$0.707P + 0.991N = 800$

$0.707(0.342N) + 0.991N = 800$

$N = 649\ N$

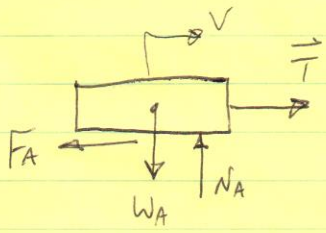
$P = 0.342(649\ N) = 222\ N$

$\boxed{222 \le P \le 479\ N}$

PROB. 8.13

a) $\mu_S = 0.4$, $\mu_K = 0.3$ FIND $P_{min}$

FBD BLOCK A:

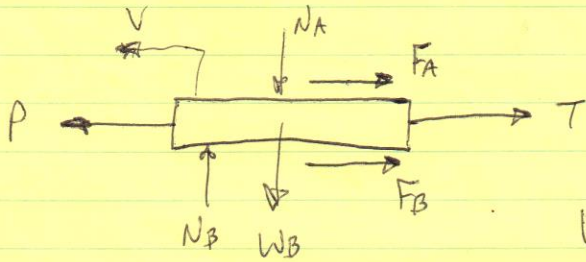



$\Sigma F_x = 0$: $T = F_A$

$\Sigma F_y = 0$: $N_A = W_A$

$W_A = (20\ kg)(9.81\ \frac{m}{s^2}) = 196\ N$

FBD BLOCK B:




$\Sigma F_x = 0$: $F_A + F_B + T = P$

$\Sigma F_y = 0$: $N_B = N_A + W_B$

$W_B = (30)(9.81) = 294\ N$

$N_B = W_A + W_B$

$F_B = \mu_S N_B = \mu_S (W_A + W_B)$

$F_A = \mu_S N_A = \mu_S W_A$ [$= T$ FROM FBD A]

$P = F_A + F_B + T$

$= (\mu_S W_A) + [\mu_S (W_A + W_B)] + (\mu_S W_A)$

$= \mu_S (3W_A + W_B)$

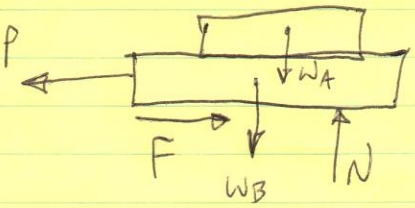
$P = (0.4)[3(196\ N) + (294\ N)]$

$\boxed{P = 353\ N}$

8.13

b) NO CABLE

FBD:




$\Sigma F_x = 0: \quad P = F$

$\Sigma F_y = 0: \quad N = W_A + W_B$

$P = F = \mu_s N = \mu_s (W_A + W_B)$

$P = (0.4)(196 + 294) = 196\ N$