# CHAPTER 9 FRICTION

## INTRO: APPLICATIONS

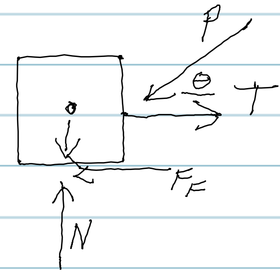
1) NO SLIDING

$\Sigma F_x = 0$

$+T - F_F = 0$

$\underline{\underline{F_F = T}}$

ROUGH SURFACE




2) IMPENDING SLIDING

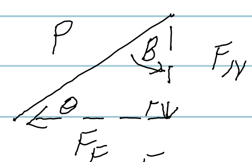
$F_f = \mu F_N = \mu N$

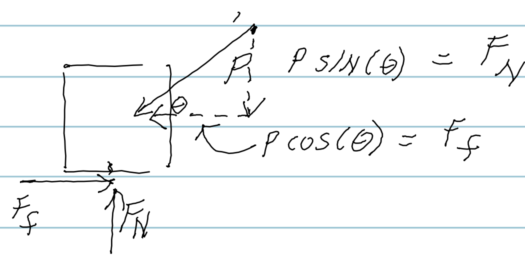
DRY FRICTION MODEL

3) NOTE: $F_f$ OPOSITE DIRECTION TO IMPENDING SLIDING

## APPLICATION 1 — ANGLE OF FRICTION

IMPENDING SLIDING




$\tan(\theta) = \dfrac{F_N}{F_F} \Rightarrow F_N = F_F \tan(\theta) \Rightarrow F_F = \mu F_N$

$\tan\theta = \dfrac{1}{\mu}$ {AT IMPENDING SLIDING}

NOT TRUE: A VERY LARGE FORCE WILL ALWAYS CAUSE SLIPPING. — NOT TRUE

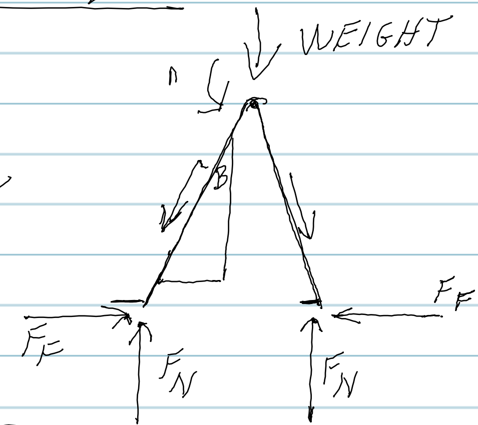
θ IS SMALLER THAN CRITICAL VALUE — NO SLIPPING. $\theta = \tan^{-1}\left(\frac{1}{\mu}\right)$

$B = \tan^{-1}(\mu)$ { NO SLIPPING FOR B GREATER THAN EQUATION RESULT.

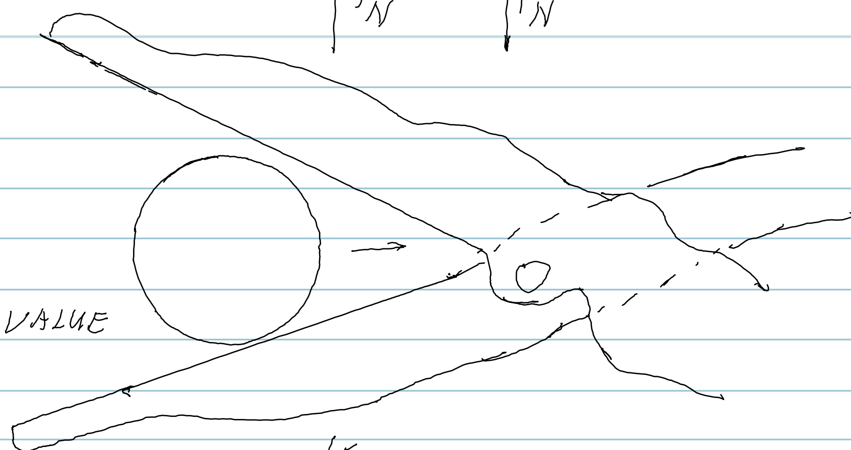
# CHAPTER 9 APPLICATIONS (CONT.)

APP 1. (CONT.)

$TAN\ \beta = \mu$



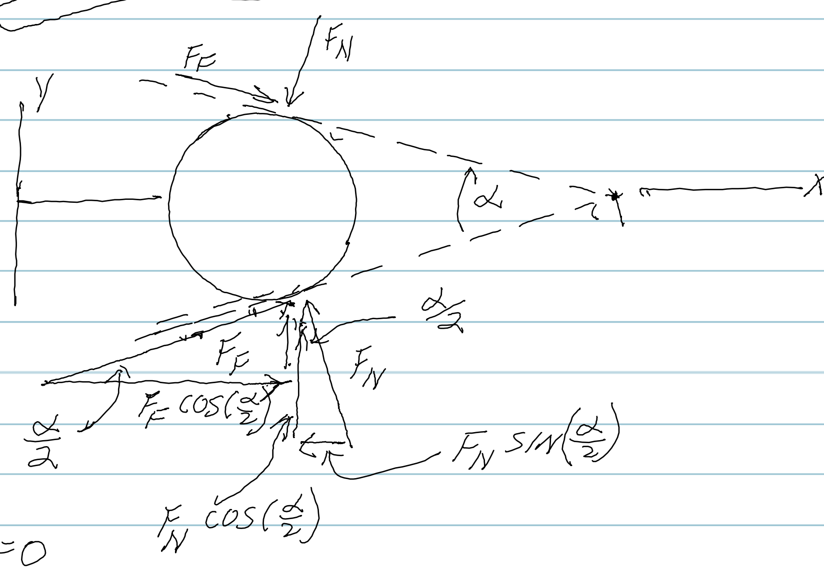

PROB 9-34



GIVEN: $\mu = .36$

FIND: $\alpha = ?$ LARGEST VALUE WITH NO SLIPPAGE

SOLUTION:




$\Sigma F_x = 0$

$2F_F\cos(\frac{\alpha}{2}) - 2F_N \sin(\frac{\alpha}{2}) = 0$

$F_F = \mu F_N$

$2\mu F_N \cos(\frac{\alpha}{2}) - 2F_N \sin(\frac{\alpha}{2}) = 0$

$\cancel{2}\mu \cancel{F_N} \cos(\frac{\alpha}{2}) = \cancel{2}\cancel{F_N} \sin(\frac{\alpha}{2}) = 0$

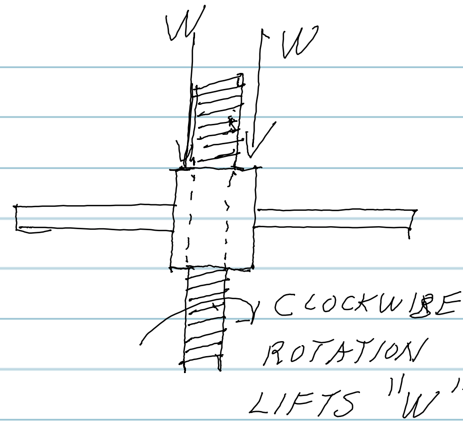
$\mu \cos(\frac{\alpha}{2}) = \sin(\frac{\alpha}{2})$

$\mu = \frac{\sin(\frac{\alpha}{2})}{\cos(\frac{\alpha}{2})} = \tan(\frac{\alpha}{2})$

$\frac{\alpha}{2} = \tan^{-1}(\mu) \Leftarrow$ CRITICAL $\alpha$

$\alpha = 2\tan^{-1}(.36) = 40^\circ$ FOR $\alpha \leq 40^\circ$ NO SLIP

## CH 9.3 THREADS




APPLICATION 3)

PITCH = DISTANCE ADVANCED IN 1 REV.

$20 \frac{REV}{IN}$ $\quad p = \frac{1}{20 \frac{REV}{in}} = .05 \frac{in}{REV}$

$$\underline{\underline{\tan\alpha = \frac{p}{2\pi r}}}$$ where: $r$ = RADIUS OF THREAD

$$\theta_s = \tan^{-1}(\mu_s)$$

MOMENT REQUIRED TO LIFT (TIGHTED)

lbs; PITCH & RADIUS

$$M = (r)(F)\tan(\theta_s + \alpha) = r(W)\tan(\theta_s + \alpha)$$

MOMENT TO LOWER (LOOSEN) IS:

$M = (r)(F)\tan(\theta_s - \alpha) \Rightarrow$ NOTE $-\alpha$ IS CHANGE {PITCH & R}

$\theta_s < \alpha$ THEN TAN(NEG ANGLE)

FIND $M = \underline{\underline{-}}$ $\quad$ LOOSEN

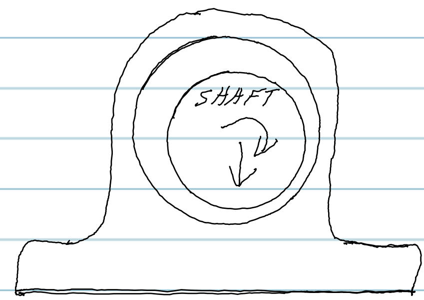
CRITICAL $\theta_s = \alpha$ LOOSEN AUTOMATICALLY

## CH. 9.4 BEARINGS, JOURNAL

BUSHING

$\Sigma M = 0$

$M = rF \sin(\theta_s)$

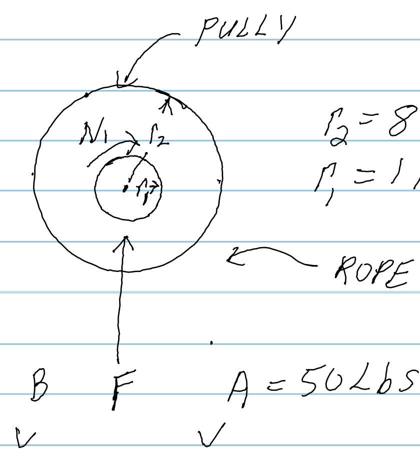



$\theta_s = \tan^{-1}(\mu_s)$


APPLICATION: 9-102

GIVEN: $\mu_s = .15$

FIND: $B = ?$ FOR MOTION




$r_2 = 8\ in$
$r_1 = 1\ in$

SOLUTION: $\theta_s = \tan^{-1}(\mu_s) = \tan^{-1}(.15)$

$\theta_s = 8.53°$

$M = rF\sin(\theta_s) = (1in)F\sin(8.53°)$

$\Sigma F_y = 0 \Rightarrow F = B + A = 50 + B$ (lbs)

$\underline{\underline{M = 1(50+B).1483 = 7.416 + .1483B}}$

$\Sigma M_o = 0$

$+B(8'') - M \pm (F)\cancel{0} - (50)8 = 0 \Rightarrow 8B - [7.416 + .1483B] - 400 = 0$

$-407.416 + 7.852B = 0$

$B = 51.9\ lbs \ \underline{\underline{\simeq 52\ lbs}}$

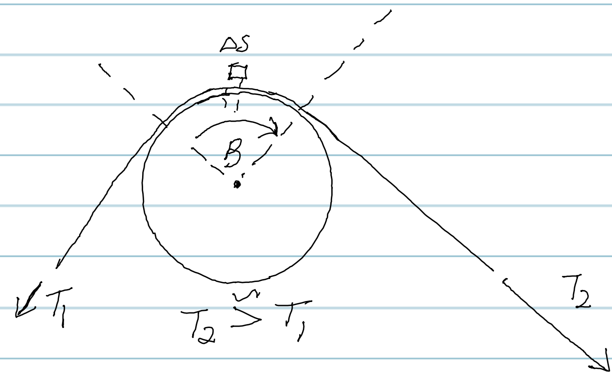
NOTE: REDUCE B UNTIL IT STARTS TO LOWER

$\frac{B}{A} = \frac{51.888}{50} = 1.0377$ 105% $\Rightarrow$ 105

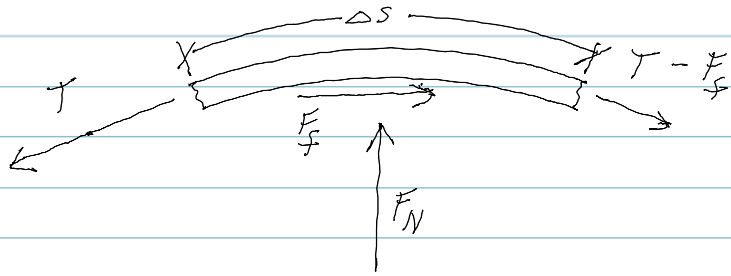
# SECTION 9.6 BELT FRICTION

CONTACT ANGLE - $B_{rad}$ ⇐ V.I.P.

$$T_2 = T_1 e^{u_s B_{rad}}$$




$T_2$ FORCE IS LIMIT
WHERE SLIPPING IN THE
DIRECTION OF $T_2$ OCC.




INITIALLY -
$T_1 = T_2$

$T_2 \gg$
$$\Sigma T = T_1 + T_2$$
$$\Delta T_2 = -\Delta T_1$$

EXAMPLE: $T_1 = T_2 = 100$ Lbs
$T_2 = 120$ Lbs $\Rightarrow$ $T_1 = 80$ Lbs

NET FORCE = 40 Lbs @ "r" of the pully

$M = T = F \cdot r \Rightarrow T_2 = 140$ Lbs $\quad T_1 = 60$ Lbs

$$T_2 = T_1 e^{u_s B} \Rightarrow \frac{T_2}{T_1} = e^{u_s B}$$

$$\frac{T_2}{T_1} = \frac{140}{60} = 2.33 \Rightarrow \frac{T_2}{T_1} = \frac{1040}{960} = 1.08$$

EXAMPLE: GIVEN: $B = 57^\circ \left(\frac{2\pi \text{ rad.}}{360^\circ}\right) = .99 \text{ rad}, \; u_s = .3$

FIND: $\frac{T_2}{T_1} = e^{u_s B} = e^{(.3).99} = e^{.2983} = 1.35 = 135\%$