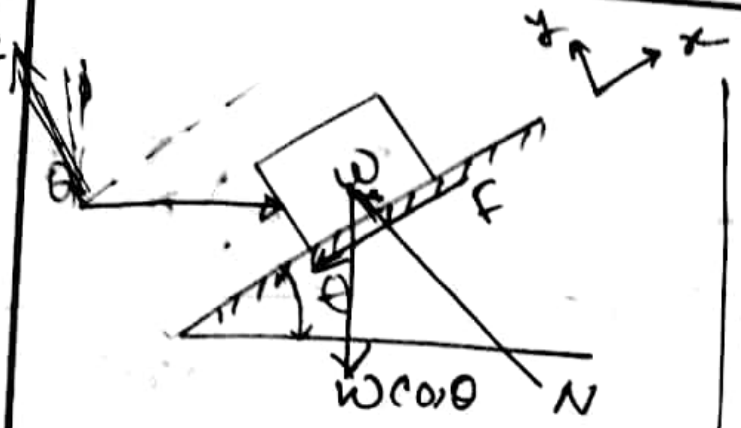
Friction

404.



$f_s = 0.4$.

$W = 100\,lb$.

$Q = 100\,lb$.

Largest angle, $\alpha = \theta$?

Smallest angle, $\theta = ?$

For smallest angle,

$\Sigma F_y = 0$.

$N - W\cos\theta - Q\sin\theta = 0$.

$N = 100\cos\theta + 100\sin\theta$ ——— (1)

$\Sigma F_x = 0$.

$Q\cos\theta - F - W\sin\theta = 0$.

$\Rightarrow 100\cos\theta - 100\sin\theta - fN = 0$.

$\Rightarrow 100\cos\theta - 100\sin\theta - 0.4(100\cos\theta + 100\sin\theta) = 0$.

$\Rightarrow 100\cos\theta - 100\sin\theta - 40\cos\theta - 40\sin\theta = 0$.

$\Rightarrow 60\cos\theta - 140\sin\theta = 0$.

$\Rightarrow \tan\theta = \frac{60}{140}$

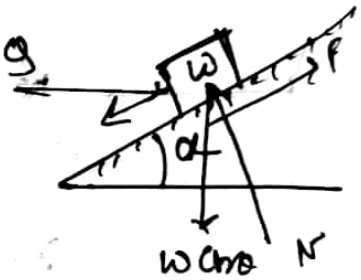
$\therefore \theta = 23.2^\circ$. Ans

For largest angle;

$\Sigma F_y = 0.$

$N - W\cos\alpha - Q\sin\alpha = 0.$

$\Rightarrow N = 100\cos\alpha + 100\sin\alpha$ — (1)



$\Sigma F_x = 0.$

$Q\cos\alpha - W\sin\alpha + P = 0.$

$\Rightarrow 100\cos\alpha - 100\sin\alpha + 40\sin\alpha + 40\cos\alpha = 0.$

$\Rightarrow 140\cos\alpha - 60\sin\alpha = 0.$

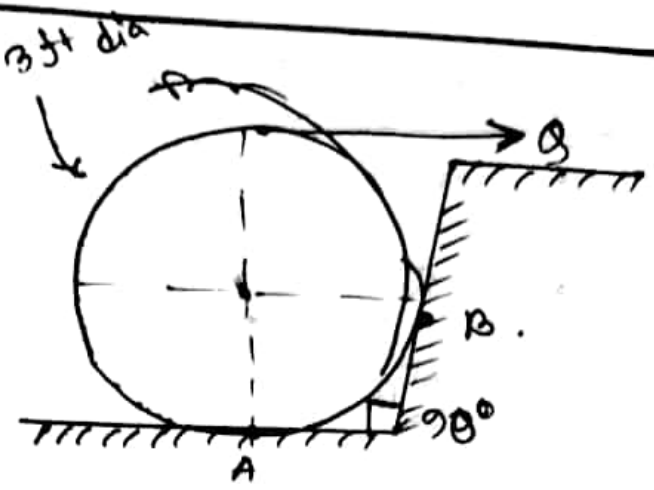
$\Rightarrow \tan\alpha = \frac{140}{60}$

$\alpha = 66.80^\circ.$ (Ans)

(+↺ ↻-)

419

$f_A = f_B = \mu_s$.



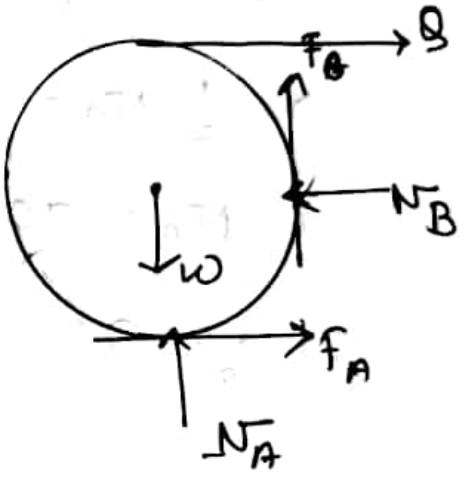
For Spanning;

$\Sigma M_A = 0$.

$Q \times 3 - N_B \times \cos 1.5 - f_B \times 1.5 = 0$.

$\Rightarrow Q \times 3 - N_B \times 1.5 - f N_B \times 1.5 = 0$.

$\Rightarrow 3Q - 2N_B = 0$ ——— (I).



$\Sigma F_y = 0$.

$N_A - W + f_B = 0$.

$\Rightarrow N_A + \frac{N_B}{3} = 300$ ——— (II)

$\Sigma F_x = 0$.

$f_A - N_B + Q = 0$. $\Rightarrow \frac{1}{3} N_A - N_B + Q = 0$ ——— (III)

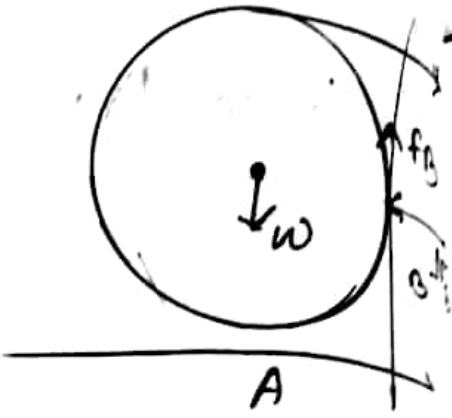
$\Rightarrow$ solving (I) eqn. (II) and (III),

$N_A = 225$ lb

$N_B = 225$ lb

$Q_s = 150$ lb.

For rolling;



$\Sigma f_x = 0.$

$N_B - Q = 0.$

$\Rightarrow Q = N_B$

$\Sigma f_y = 0.$

$F_B - \omega = 0.$

$\Rightarrow \frac{1}{3} N_B = \omega.$

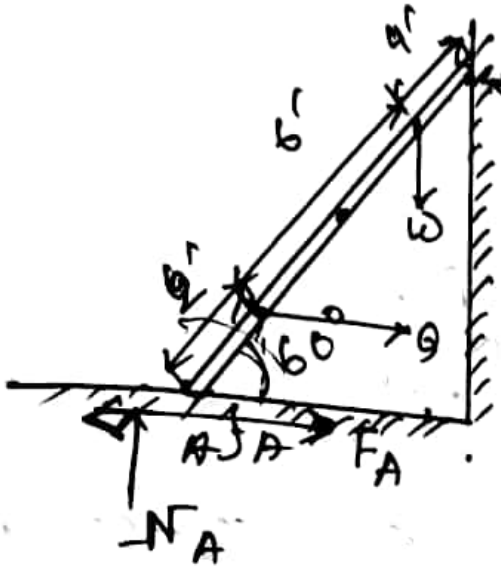
$\Rightarrow N_B = 900.$

$\therefore Q_p = 900$ lb.

Here $Q_s < Q_p.$

So, It will be spinning.

121.



$f_A = 0.2$

$f_B = 0.3$.

$W = 500$ lb

$Q = ?$.

$\Sigma M_A = 0$.

$Q \sin 60° \times 12 + W \times 8 \cos 60° - N_B \times 12 \sin 60° + F_B \times 12 \cos 60° = 0$.

$\Rightarrow \sqrt{3}Q + 2000 - 6\sqrt{3}N_B + 6 \times 0.3 \times N_B = 0$.

$\Rightarrow \sqrt{3}Q + 2000 - N_B(6\sqrt{3} - 6 \times 0.3) = 0$.

$\Rightarrow \sqrt{3}Q + 8.60 N_B = -2000$ ——— (1).

$\Sigma f_x = 0$.

$Q - f_A + Q - N_B = 0$.

$\Rightarrow -0.2N_A + Q + N_B = 0$ ——— (2)

$\Sigma f_y = 0$.

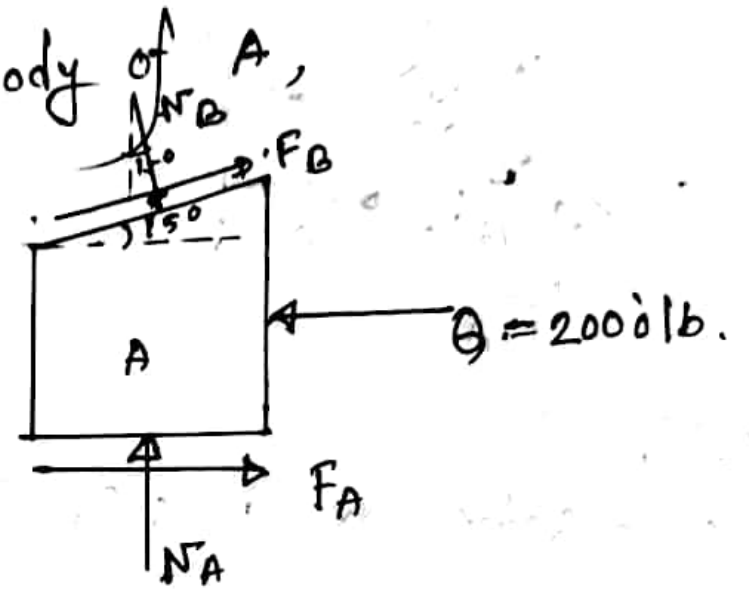
$N_A - F_B - W = 0$.

$\Rightarrow N_A - 0.3 \times N_B - W = 0$.

By solving the above eqns.

$\theta = 441$ lb. Ans

427.] Consider the free body of A,



$f = 1/3$

$\Sigma f_x = 0.$

$$F_A - \theta + F_B \cos 15^\circ + N_B \sin 15^\circ = 0.$$

$$\Rightarrow f N_A - 2000 + f N_B \cos 15^\circ + N_B \sin 15^\circ = 0.$$

$$\Rightarrow N_A - 6000 + N_B \cos 15^\circ + 3 N_B \sin 15^\circ = 0$$

$$\Rightarrow N_A + N_B 1.74 = 6000 \quad \text{(10)}$$

$\Sigma f_y = 0.$

$$N_A + F_B \sin 15^\circ - N_B \cos 15^\circ = 0.$$

$$\Rightarrow N_A + \frac{1}{3} N_B \sin 15^\circ - N_B \cos 15^\circ = 0.$$

$$\Rightarrow 3 N_A + N_B \sin 15^\circ - 3 \cos 15^\circ N_B = 0.$$

$$\Rightarrow 3 N_A - 2.64 N_B = 0 \quad \text{(9)}$$

$\therefore N_A = 2015.27$ lb.

$N_{AB} = 2290.08$ lb.

Now, consider B,

$\Sigma F_x = 0.$

$N_B - f_{AB}\cos 16^\circ - N_{AB}\sin 15^\circ = 0$

$\Rightarrow N_B = f \times N_{AB}\cos 15^\circ + N_{AB}\sin 15^\circ N_B$

$= 0 \quad \frac{2290.08}{3}\cos 15^\circ + \frac{2290^\circ}{3}\sin 15^\circ$

$N_B = 1330.5$ lb.

$\Sigma F_y = 0.$

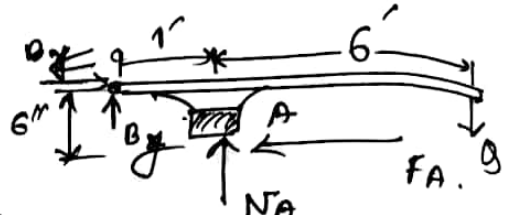
$N_{AB}\cos 15^\circ - f_{AB}\sin 15^\circ - f_B - W_B = 0.$

1330

$\Rightarrow W_B = 2290.08\cos 15^\circ + \frac{2290.08\sin 15^\circ + 1330 \times \frac{1}{3}}{3}$

$\therefore W_B = 1571$ lb.

923.



$\Sigma M_B = 0$.

$F_A \times 0.5 - N_A \times 1 + Q \times 7 = 0$

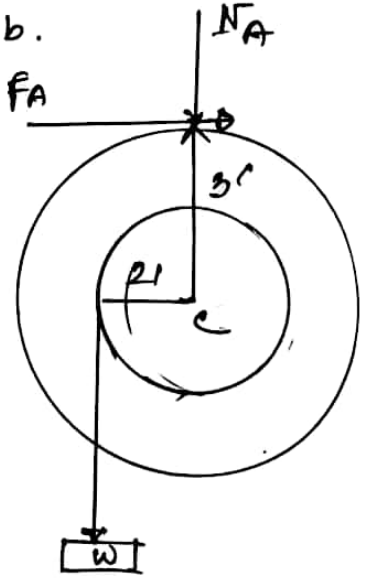
$\Rightarrow \frac{N_A}{3} \times 0.5 - N_A + Q \times 7 = 0$.

$\Rightarrow N_A = 1260$ lb.

$\therefore f_A = \frac{1260}{3} = 420$ lb.

$\Sigma F_Q = 0$.

$\Sigma M_C = 0$



$W \times 2 - F_A \times 3 = 0$.

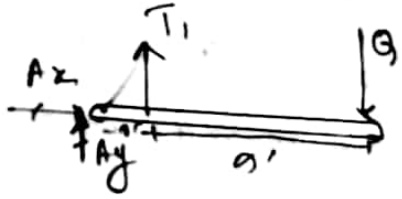
$\Rightarrow W = \frac{420 \times 3}{2}$

$W = 630$ lb. (Ans.)

$\Sigma M_A = 0$.

$\Rightarrow Q \times 10 - T_1 \times 1 = 0$.

$\Rightarrow T = 1500\,lb$



Now, considering the free body diagram of the drum,

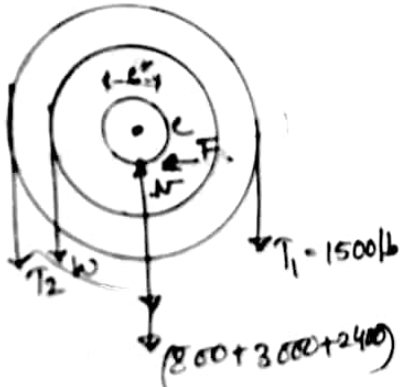
Now,

$T_1 = T_2 e^{\mu\theta}$.

$\Rightarrow T_2 = \dfrac{T_1}{e^{\mu\theta}}$

$= \dfrac{1500}{e^{(0.42)}}$

$= 526.38\,lb$.



$\theta = 180^\circ = \pi$.

$\Sigma F_y = 0$.

$\Rightarrow N = T_1 + T_2 + W + 6200$.

$= 8226.38 + W$

$\therefore F = 0.12(8226.38 + W)$. ——— (1)

$\Sigma M_c = 0$

$\Rightarrow T_1 \times 4 - \omega \times 3 - T_2 \times 4 + F \times \frac{3}{12} = 0.$

$\Rightarrow 1500 \times 4 - \omega \times 3 - 0.526.38 \times 4 + \frac{3}{12} \times 0.12 (8226.38)$

$\Rightarrow -0.03\omega + 3\omega = 4141.27.$

$\Rightarrow 2.97\omega = 4141.27$

$\therefore \omega = 1394.37$ lb. (Ans.)

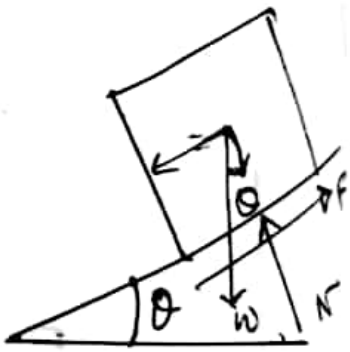
438. Consider the free body will slide. or,

$\Sigma f_x = 0.$

$f - \omega \sin\theta = 0$

$\Rightarrow f = \omega \sin\theta.$

$\Rightarrow 0.2N = \omega \sin\theta$ —— (I)



$\Sigma f_y = 0.$

$N = \omega \cos\theta.$ —— (II)

$\Rightarrow$ ~~$\tan\theta$~~ =

(I) $\div$ (II) $\Rightarrow \tan\theta = 0.2$

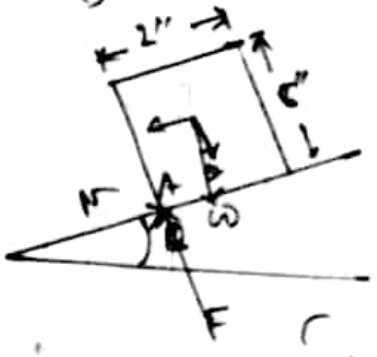
$\Rightarrow \theta = 11.31^\circ.$

Now, consider the body will tip over,

$\Sigma M_A = 0.$

$W \sin\theta' \times 4 - W\cos\theta' \times 1 = 0.$

$\Rightarrow \frac{W\sin\theta'}{W\cos\theta'} = \frac{1}{4}.$



$\Rightarrow \tan\theta' = 0.25$

$\therefore \theta' = 14.036°.$

Hence,

$\theta' > \theta$, the body will slide

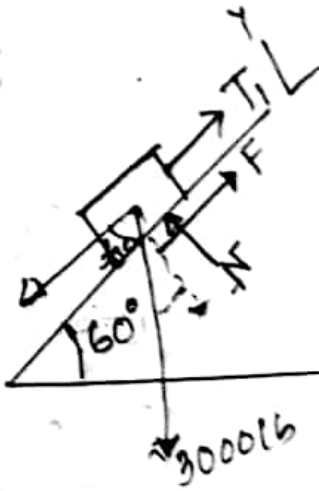
499.

$\Sigma F_y = 0.$

$N - W\cos 60° = 0.$

$\Rightarrow N = 3000 \cos 60°$

$= 1500 \text{ lb} \quad \therefore F = 450 \text{ lb}.$



$\Sigma F_x = 0.$

$F + T_1 - W\sin 60° = 0.$

$\Rightarrow 450 + T_1 - 3000 \sin 60° = 0.$

$\Rightarrow T_1 = 2148.08 \text{ lb}.$

Now, considering the free body of the wheel

$T_2 = T_3 e^{f\theta}$.

$\Rightarrow T_2 = T_3 e^{0.3 \times (\pi/2 \times 3)}$

$= 4.11\, T_3$ ——— (1)

$\theta = 270° = \frac{3\pi}{2}$

$f = 0.3$.

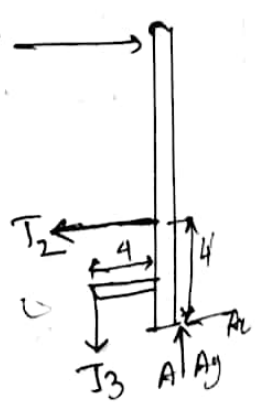
$\Sigma M_c = 0$.

$-2148.08 \times 4 + T_2 \times 6.12 - T_3 \times 12 = 0$.

$\Rightarrow -2148.08 \times 4 + 4.11 \times 12 \times T_3 - T_3 \times 12 = 0$.

$\Rightarrow T_3 = 230.23$ #.

Now, $\therefore T_2 = 946.2616$.



$\Sigma M_A = 0$.

$Q \times 20 - T_2 \times 4 - T_3 \times 4 = 0$.

$\Rightarrow Q \times 20 - 946.26 \times 4 - 230.23 \times 4 = 0$

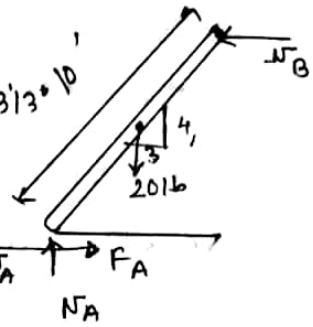
$Q = 235.298$ lb. (Ans)

(+↻) (−)

446. consider the freebody diagram of the ladder,

$\Sigma M_B = 0.$

$\Rightarrow N_A \times 10\cos 53.13^\circ - F_A \times 10\sin 53.13^\circ \times 10' - 20\cos 53.13^\circ = 0.$



$\Rightarrow N_A \times 10\cos 53.13^\circ - 0.5 \times 10 \times \sin 53.13^\circ \times N_A - 5\cos 53.13^\circ = 0.$

$\tan\theta = \frac{4}{3}$

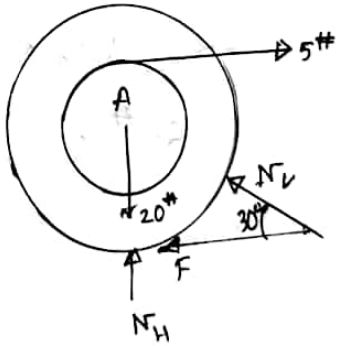
$\theta = 53.13^\circ.$

$\cos 53.13^\circ =$

$\Rightarrow N_A = 30$ lb.

$\therefore F_A = 15$ lb. (Ans.)

447. considering the free body,



$\Sigma M_A = 0.$

$5 \times 3 - F \times 5 = 0.$

$\Rightarrow F = 3$ lb

$\therefore N_V = 6.67$ lb.

$\Sigma F_y = 0.$

$\Rightarrow N_A + N_V \sin 30^\circ + F_B \sin 60^\circ - 20 = 0.$

$\Rightarrow N_A = 20 - 6.67\sin 30^\circ - 3\sin 60^\circ = 14.07$ lb.

$\therefore$ Reaction of Horizontal plane $N_A = 14.07$ lb (Ans)

448. Consider the free body of the homogeneous body.

$\Sigma F_x = 0.$

$F - P\cos 67'38° = 0.$

$\Rightarrow 0.5N = P\cos 67'38°$

$\Rightarrow N = 0.769P$ ——①

$\Sigma F_y = 0.$

$-N + P\sin 67'38° - N\cos 0 - 30 = 0.$

$\Rightarrow P\sin 67'38° - 0.769P - 30 = 0.$

$\Rightarrow P = 195\,lb.$

$\tan\theta = \frac{12}{5}$

$\theta = 67'38°$

The block A will be equilibrium at 260#.

(+↻) (−↺)

150. Considering the drum,

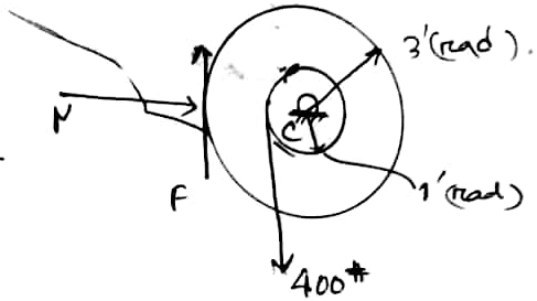
$\Sigma M_c = 0$.

$F \times 3 - 400 \times 1 = 0$.

$\Rightarrow F = \frac{400}{3} = 133.33\#$

$\therefore N = 133.33 \times 2$

$= 266.67\#$ (Ans)



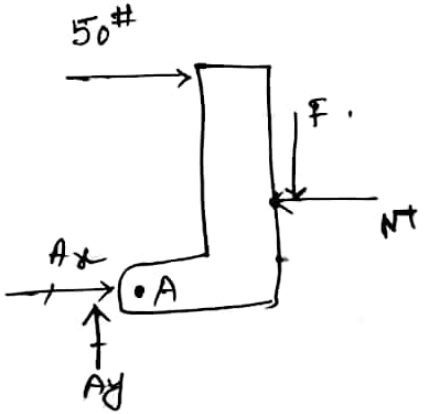
Now,

$\Sigma F_x = 0$.

$A_x + 50 - N = 0$

$\Rightarrow A_x = 266.67 - 50$

$= 216.67$ lb (Ans)



$\Sigma F_y = 0$.

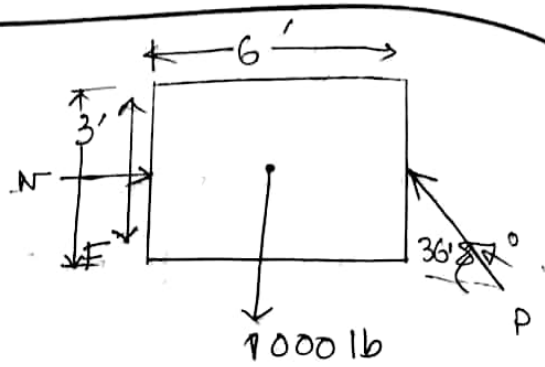
$A_y - F = 0$.

$A_y = 133.33$ lb. (Ans)

454.

$\tan\theta = \frac{3}{4}$

$\theta = 36.87^\circ$



considering the free body of the block.

$\Sigma F_x = 0$

$N - P\cos 36.87^\circ = 0.$

$\Rightarrow N = P\cos 36.87^\circ$ —— (1)

$\Sigma F_y = 0.$

$P\sin 36.87^\circ - 1000 + F = 0.$

$\Rightarrow P\sin 36.87^\circ - 1000 + 0.2P\cos 36.87^\circ = 0.$

$\Rightarrow P(\sin 36.87 + 0.2\times\cos 36.87^\circ) = 1000$

$\Rightarrow P = 1315.789$ lb.

160

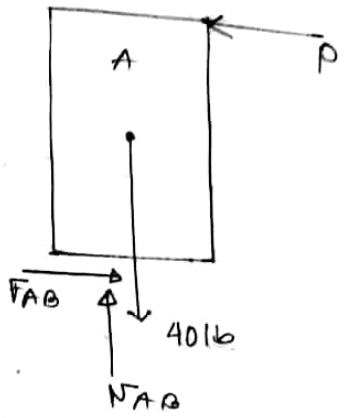
Case: I If block A is sliding

$\Sigma f_y = 0$

$N_{AB} = 40$

$\Rightarrow f_{AB} = 0.40 \times 40$

$= 16^{\#}$.



$\Sigma f_x = 0$

$P - f_{AB} = 0.$

$P = 16^{\#}.$

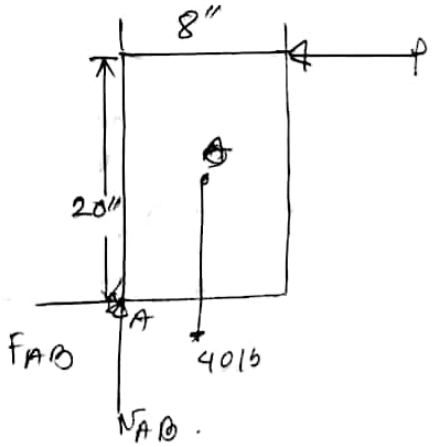
Case - II:

If block A is tip overs,

$\Sigma M_A = 0.$

$40 \times 4 - P \times 20 = 0.$

$\Rightarrow P = 8\ lb.$



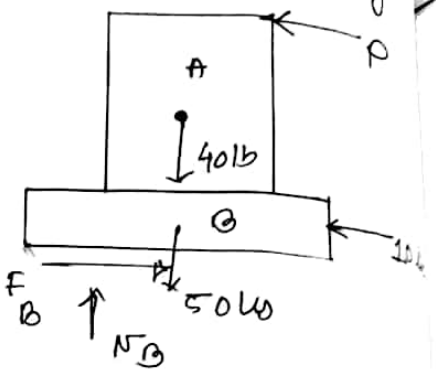
Case-III: Both block A and B are sliding

$\Sigma f_y = 0$

$N_B = 90.$

$\Rightarrow f_D = 90 \times 0.30$

$= 27$ lb



$\Sigma f_x = 0.$

$F_B = 10 + P.$

$\Rightarrow P = 17$ lb.

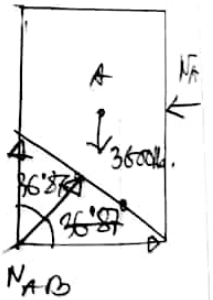
Since force $P = 8^{\#}$ is small the body A will tip over.

461. Considering the free body of block A,

$\Sigma f_y = 0.$

$N_{AB} \cos 36'87^0 - 3600 = 0.$

$\Rightarrow N_{AB} = 4500$ lb.



$\theta = \tan^{-1}\frac{3}{4}$

$= 36'87^0.$

Considering the free body diagram of block B,

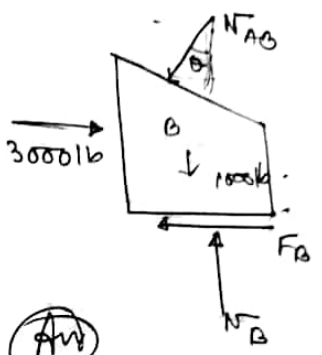
$\Sigma f_y = 0.$

$N_B - 1000 - N_{AB}\cos 36'87° = 0$

$\Rightarrow N_B = 1000 + N_{AB}\cos 36'87°$

$= 4600\ \#.$

$\therefore f_B = 4600 \times 0'10 = 460\ \#.$



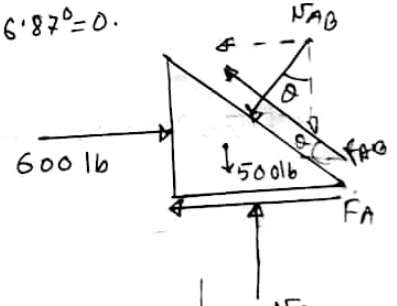
Ans

Q2. Considering the free body of A,

$\Sigma f_y = 0.$

$N_A - 500 - N_{AB}\cos 36'87° + f_{AB}\sin 36'87° = 0.$

$\Rightarrow N_A = 500 + 0'5 N_{AB}$ —①



$\Sigma F_x = 0.$

$600 - N_{AB}\sin 36'87° + f_{AB}\cos 36'87° - F_A = 0$

$\Rightarrow 600 - 0'5 N_A - N_{AB}\sin 36'87° - 0'5 \times N_{AB}\cos 36'87° = 0$

$\theta = \frac{1'3}{4} = 36'87°.$

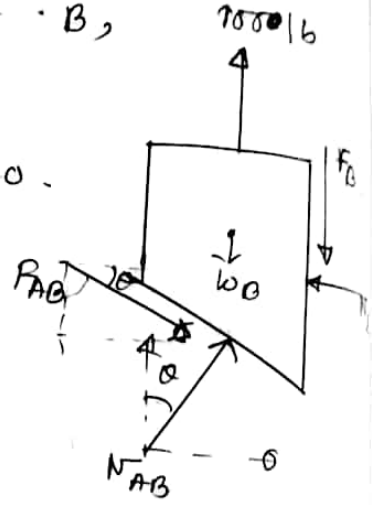
$\Rightarrow 600 - 0'5(500 + 0'5 N_{AB}) - N_{AB} \times 0'6 - 0'4 \times N_{AB} = 0.$

$\Rightarrow 600 - 250 - 0'25 N_{AB} - 0'6 N_{AB} - 0'4 N_{AB} = 0.$

$\Rightarrow N_{AB} = \frac{300}{1'25} = 280\ \#$

$\therefore F_{AB} = 140\#$

considering the freebody of B,



$\Sigma F_x = 0$.

$F_{AB}\cos 36.87° + N_{AB}\sin 36.87° - N_B = 0$.

$\Rightarrow N_B = 280\#$.

$F_B = 280 \times 0.4 = 112\#$

$\Sigma F_y = 0$.

$N_{AB}\cos 36.87° - F_{AB}\sin 36.87° + 1000 - F_B - W_B = 0$.

$\Rightarrow W_B = 280\cos 36.87° - 140\sin 36.87° + 1000 - 112$

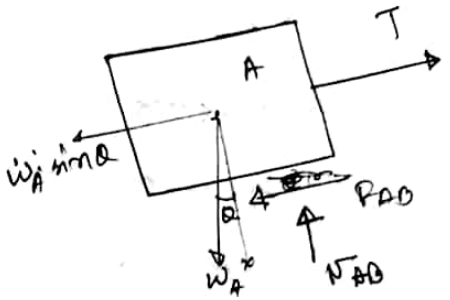
$\therefore W_B = 128\#$. (Ans)

Considering the free body of A,

$\Sigma F_x = 0$.

$T - W_A \sin\theta - F_{AB} = 0$.

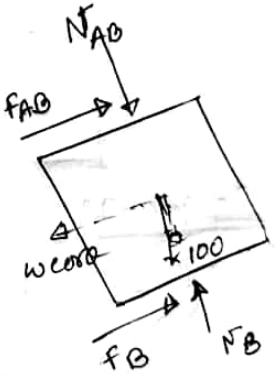
$\Rightarrow T = 50\sin\theta - F_{AB}$ — (I)



$\Sigma F_y = 0$.

$N_{AB} - W_A\cos\theta = 0 \Rightarrow N_{AB} = W_A\cos\theta$ — (II)

Consider the free body of B,



$\Sigma F_x = 0$

$F_{AB} + F_B - W\cos\theta = 0$.

$\Rightarrow F_{AB} + F_B - 100\cos\theta = 0$ — (III)

$\Sigma F_y = 0$.

$N_B - N_{AB} - 100\cos\theta = 0$.

$\Rightarrow N_B = N_{AB} + 100\cos\theta$ — (IV).

(iii) $\Rightarrow 0.25 N_{AB} + 0.25 N_B - 100\sin\theta = 0$

$\Rightarrow 0.25 \times 50\cos\theta + 0.25(50\sin\theta + 100\cos\theta) - 100\sin\theta = 0$

$\Rightarrow 12.5\cos\theta + 12.5\cos\theta + 25\cos\theta = 100\sin\theta$.

$\Rightarrow 50\cos\theta = 100\sin\theta$.

$\Rightarrow \tan\theta = 0.5$

$\theta = 26.57^\circ$

(ii) $\Rightarrow T = 50\sin 26.57^\circ + 0.25 \times N_{AB}$.

$= 22.36 + 0.25 \times 50 \times \cos 26.57^\circ$

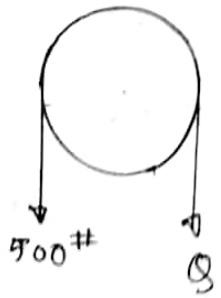
$= 33.54\#$. (Ans.)

479. Case-I: When $Q > P$.

$\Rightarrow Q = P e^{f\theta}$.

$= 500\, e^{0.4 \times \pi}$

$= 1756.80\#$. (Ans).



Case-II: When $P > Q$

$\Rightarrow P = Q e^{f\theta}$.

$\Rightarrow Q = \frac{P}{e^{f\theta}} = \frac{500}{e^{0.4\times\pi}}$

$= 142.30\#$. (Ans)

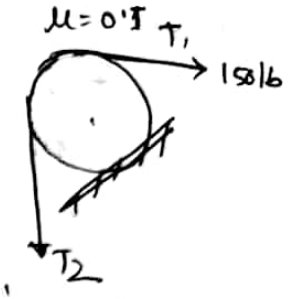
Consider the 1st belt and shaft.

$T_1 = T_2 e^{f\theta}$

$\Rightarrow T_2 = \frac{T_1}{e^{f\theta}}$

$= \frac{150}{e^{0.1 \times \pi/2}}$

$T_2 = 128.2$ lb



$f = 0.1$

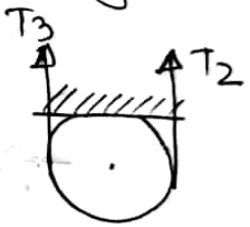
$\theta = \frac{\pi}{2}$.

Now, consiging the 2nd belt and shaft.

$T_2 = T_3 e^{f\theta}$

$T_3 = \frac{T_2}{e^{f\theta}} = \frac{128.2}{e^{0.2 \times \pi}}$

$T_3 = 68.4$ lb



$\mu = f = 0.2$

$\theta = \pi$

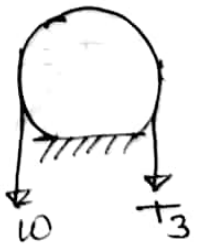
Considering 3rd shaft,

$T_3 = \omega e^{f\theta}$

$\Rightarrow \omega = \frac{T_3}{e^{f\theta}} = \frac{68.4}{e^{0.1 \times \pi}}$

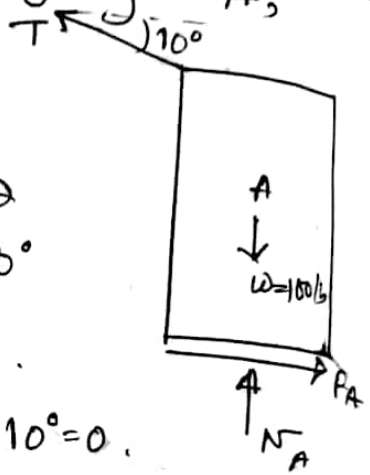
$= 50$ lb. Ans

$\mu = 0.1$



$\theta = \pi$.

482. Considering the freebody of A,



$\Sigma f_x = 0.$

$f_A - T\cos 10^\circ = 0.$

$\Rightarrow f_A = T\cos 10^\circ.$

$\Sigma f_y = 0.$ $\Rightarrow N_A = \frac{1}{0.30} T\cos 10^\circ$

$N_A - 100 + T\sin 10^\circ = 0.$

$\Rightarrow 0.30 f_A - 100 + T\sin 10^\circ = 0.$

$\Rightarrow 0.30 \times T\cos 10^\circ - 100 + T\sin 10^\circ = 0.$

$\Rightarrow T(0.30\cos 10^\circ + \sin 10^\circ) = 100$

$\Rightarrow N_A - 100 + \frac{f_A}{\cos 10} \times 0.30 = 0$

$\Rightarrow T \cdot \frac{\cos 10^\circ}{0.30^\circ} - 100 + T\sin 10^\circ = 0$

$T = 28.93$ lb.

Now, considering the shaft,

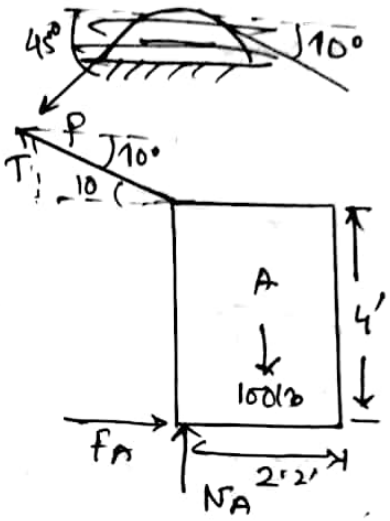
Case – II : If the body tip over,

$\Sigma M_0 = 0$.

$100 \times 1.1 - T\cos 10° \times 4$

$T = \frac{100 \times 1.1}{\cos 10° \times 4}$

$= 27.92^{\#}$.



Here $28.93 > 27.92$ lb.

So, the body will tip over.

$\therefore T = 27.92^{\#}$

Now, consider the shaft.

$P = Te^{f\theta}$.

$\Rightarrow P = 37.39$ lb.

Ans

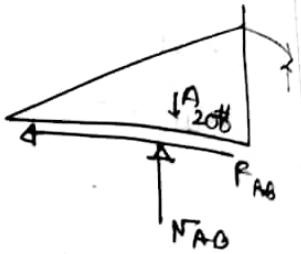
$\theta = 45° + 10° = 55°$
$= 0.31\pi$

$f = 0.3$.

486. Case-I: If the body A is sliding,

$\Sigma F_y = 0$.

$N_{AB} = 200$ lb.



$\Sigma F_x = 0$.

$T - F_{AB} = 0$.

$\Rightarrow T_1 = F_{AB} = 0.6 \times 200$

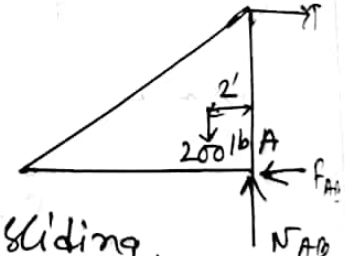
$= 120\#$.

Case-II: If the body A is tip over.

$\Sigma M_A = 0$.

$T \times 3 - 200 \times 2 = 0$

$\Rightarrow T_2 = 133.33\#$.



Case-III: If both body are sliding,

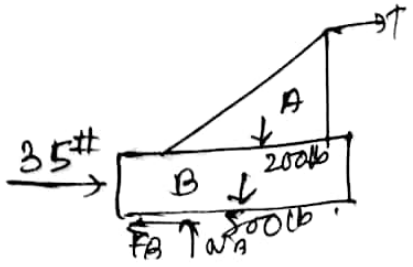
$\Sigma F_y = 0$.

$N_B - 700 = 0 \quad \therefore N_B = 700\#$.

$\Sigma F_x = 0$.

$35 - F_B + T = 0$.

$\Rightarrow T = 0.2 \times 700 - 35$



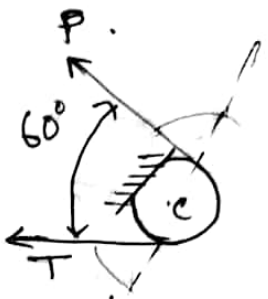
$\therefore T = 105^{\#}$ $\quad T < T_2 < T_2$.

Now consider the shaft,

$P = T e^{f\theta}$

$= 105 \times e^{0.4 \times \frac{2\pi}{3}}$

$P = 242.67$ lb.



$f = 0.4$

~~$\theta = 60°$~~

~~$= \frac{\pi}{3}$~~

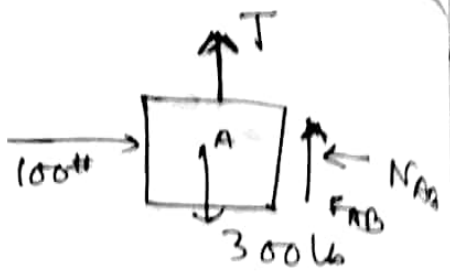
$\theta = 180° - 60°$

$= 120°$

$= \frac{2\pi}{3}$

487. When, $W_A > W_B$

Consider the ϕ A,



$\Sigma F_x = 0.$

$N_{AB} = 100.$

$F_{AB} = 30^{\#}.$

$\Sigma F_y = 0.$

$T - 300 + F_{AB} = 0.$

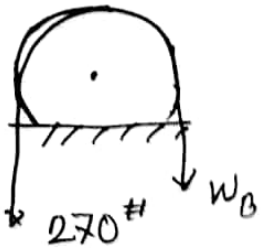
$T = 270^{\#}.$

Now, considering the belt and dream,

We know

$T = W_B e^{f\theta}.$

$W_B = \frac{270}{e^{1/4 \times \pi/2}}$



$= 99.33$ lb.

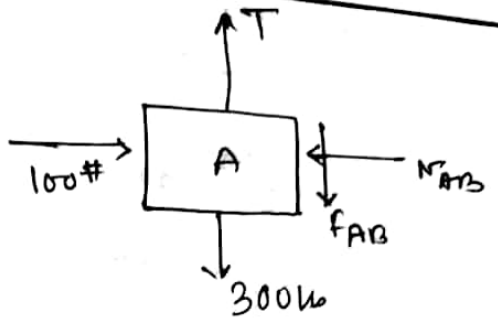
When, $W_B > W_A$.

$\Sigma F_x = 0$.

$100 - N_{AB} = 0$.

$N_{AB} = 100$

$F_{AB} = 30^{\#}$.



$\Sigma F_y = 0$.

$T - 300 - f_{AB} = 0$.

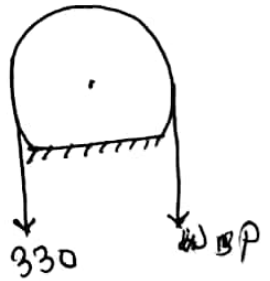
$\Rightarrow T = 330^{\#}$

considering the belt and dram,

$P = W_B e^{f\theta}$

$= 330 \times e^{1.}$

$= 893.3 lb.$



considering the body B,

$\Sigma f_x = 0$

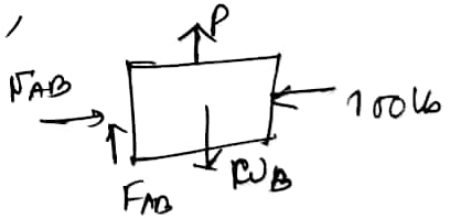
$N_{AB} = 100$.

$\Sigma f_y = 0$.

$P - W_A + F_A = 0$

$\Rightarrow P = W_B - 30$

$\therefore W_B = 893.3 + 30 = 927.3$ lb. (Ans)



571.

we get,

$1500 = 500e^{f\theta}$.

$\Rightarrow e^{f\theta} = 30$.

$\Rightarrow \frac{1}{\pi} \times 2n\pi = \ln 30$.

$n = 1.701 \approx 2$.

50lb.