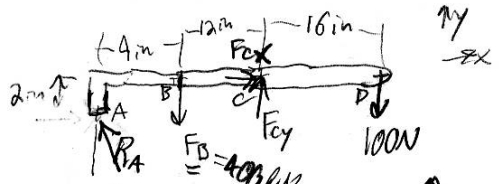
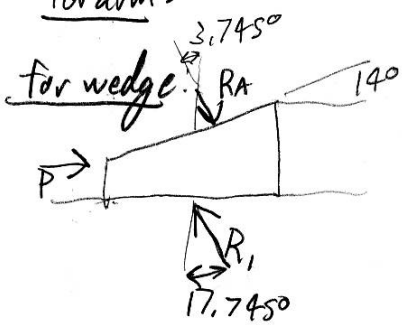
PS 10



① μ_s for surfaces considered $= .32$ for

so $\phi_s = \arctan(.32) = 17.745°$

For arm ↗



For wedge:

(a) For Arm: $\Sigma M_C = 0 = 400kN(12in) - 100N(16in) - R_A\cos(3.745°)(21in)$

$\rightarrow R_A = 228.9842kN$

For wedge: $\Sigma F_y = 0 = R_1(\cos 17.745°) - R_A\cos(3.745°)$

$\rightarrow R_1 = 239.0956kN$

$\Sigma F_x = 0 = P + R_A \sin 3.745° - R_1 \sin(17.745°)$

$P = 58.1636kN$ $(P = 58.2kN)$

(b) For Arm: $\Sigma F_x = 0 = F_{cx} - R_A\sin(3.745°)$

$F_{cx} = 14.956kN$

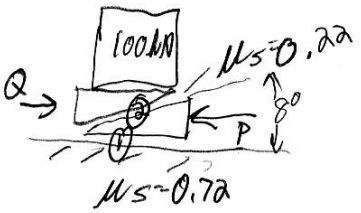
$\Sigma F_y = 0 = R_A\cos(3.745°) - 400kN + F_{cy} - 100N$

$F_{cy} = 171.605kN$

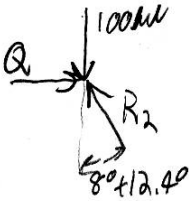
$F_{cx} = 15.0kN$

$F_{cy} = 172kN$

(2)



(a) For top:



$\phi_{s_2} = \arctan(.22) = 12.4°$

$\Sigma F_y = 0 = -100kN + R_2 \cos(20.4°)$

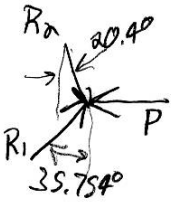
$R_2 = 106.6966kN$

$\Sigma F_x = 0 = Q - \sin(20.4°)(R_2)$

$Q = 37.19kN$

for bottom:

$\phi_{s_1} = \arctan(0.72) = 35.754°$



$\Sigma F_y = 0 = -\cos(20.4°) R_2 + R_1 \cos(35.754°)$

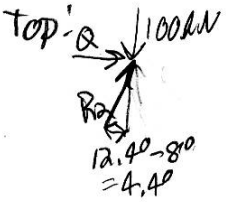
$R_1 = 123.23kN$

$\Sigma F_x = 0 = -P + R_2 \sin(20.4°) + R_1 \sin(35.754°)$

$P = 109.196kN$

$P = 109kN$, $Q = 37.2kN$

(b) top:



$\Sigma F_y = 0 = -100kN + R_2 \cos(4.4°) \rightarrow R_2 = 100.2956kN$

$\Sigma F_x = 0 = Q + R_2 \sin(4.4°) \rightarrow Q = -7.6946kN$

bottom:

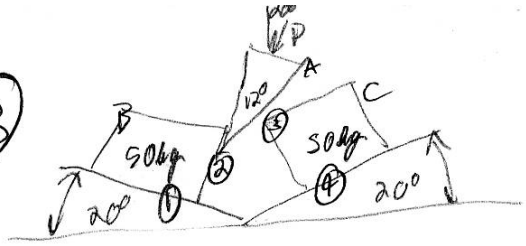
$\Sigma F_y = 0 = -R_2 \cos(4.4°) + R_1 \cos(35.754°) \rightarrow R_1 = 123.2235kN$

$\Sigma F_x = 0 = -R_2 \sin(4.4°) - R_1 \sin(35.754°) - P$

$\rightarrow P = -79.695kN$

$P = -79.7kN$, $Q = -7.70kN$

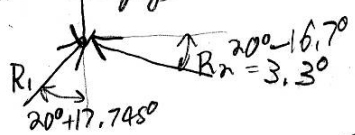
(3)



ϕ_s for 2,3,4 $= \arctan(0.30) = 16.7°$

(a) $\phi_{s,1} = \arctan(.32) = 17.745°$ ASSUMING BLOCK "B" moves first:

for B:



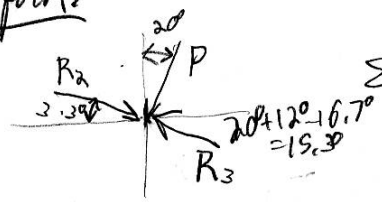
$\Sigma F_x = 0 = R_1 \sin(37.745°) - R_2 \cos(3.3°)$

$R_1 = \dfrac{R_2 \cos(3.3°)}{\sin(37.745°)}$

$\Sigma F_y = 0 = -50.0kg(9.80665 m/sec^2) + R_1 \cos(37.745°) + R_2 \sin(3.3°)$

$0 = -490.3325N + 1.347173(R_2) \rightarrow R_2 = 363.9715N$

for A:



$\Sigma F_x = 0 = R_2 \cos(3.3°) - P \sin(20°) - R_3 \cos(15.3°)$

$R_3 = \dfrac{R_2 \cos(3.3°) - P \sin(20°)}{\cos(15.3°)}$

$\Sigma F_y = 0 = -P\cos(20°) - R_2 \sin(3.3°) + R_3 \sin(15.3°)$

$= -P\cos(20°) - R_2 \sin(3.3°) + \dfrac{[R_2 \cos(3.3°) - P\sin(20°)]\sin(15.3°)}{\cos(15.3°)}$

$P\cos(20°) + \dfrac{P\sin(20°)\sin(15.3°)}{\cos(15.3°)} = R_2\left[\dfrac{\cos(3.3°)\sin(15.3°)}{\cos(15.3°)} - \sin(3.3°)\right]$

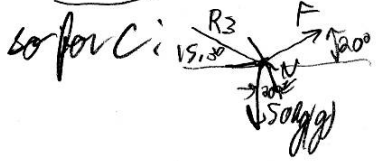
$P(1.033299) = R_2[.215551]$

$P = 75.92925N$

for this to occur:

R_3 then $= 349.7963N$

so for C:



$\Sigma F_y = -50kg(g) - \sin(15.3°)R_3 + F(\sin 20°) + N\cos(20°) = 0$

so $F = \dfrac{50kg(g) + R_3 \sin(15.3°) - N\cos(20°)}{\sin(20°)}$

$\Sigma F_x = 0 = R_3 \cos(15.3°) + F\cos(20°) - N\sin(20°)$

(3a cont.)

$$0 = R_3\cos(15.3^\circ) + \cos 20^\circ\left[\frac{50kg(g) + R_3\sin(15.3^\circ) - N\cos(20^\circ)}{\sin(20^\circ)}\right] - N\sin(20^\circ)$$

$$N\left[\sin(20^\circ) + \cot(20^\circ)\cos 20^\circ\right] = \cot(20^\circ)\,50kg(g) + R_3\cos(15.3^\circ) + R_3\cot(20^\circ)\sin(15.3^\circ)$$

$$\rightarrow \quad N = 662.8943N$$

then $\Sigma F_x = 0 \rightarrow F = -117.778N$

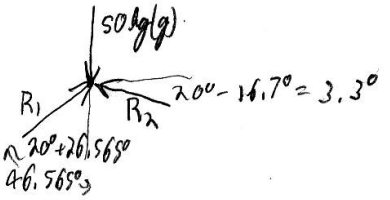
$\left|\frac{F}{N}\right|$ = required $\mu_s = .1777$

which is less than $\mu_s = .30$ for surface 4

so $\boxed{P = 75.9N}$

(3b) If B slips: for B

$\phi_{s1} = \arctan(0.50) = 26.565^\circ$



$$\Sigma F_x = 0 = R_1\sin(46.565^\circ) - R_2\cos(3.3^\circ) \rightarrow R_1 = R_2\frac{\cos(3.3^\circ)}{\sin(46.565^\circ)}$$

$$\Sigma F_y = 0 = -50kg(g) + R_1\cos(46.565^\circ) + R_2\sin(3.3^\circ)$$

$$= -50kg(g) + R_2\left[\frac{\cos(3.3^\circ)\cos 46.565^\circ}{\sin(46.565^\circ)} + \sin(3.3^\circ)\right]$$

$$\rightarrow R_2 = 488.961N$$

following the previous analysis for [A], $\rightarrow P = 102.0835N$

then $R_3 = 469.8968N$

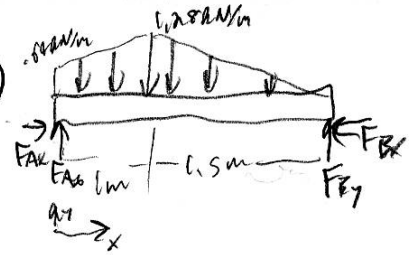
and then for C similarly: $N[2.923804] = 1247.1775N + R_3[1.689543]$

$$\rightarrow N = 732.2953N$$

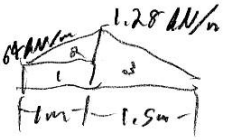
(3b cont.) and $F = -215.797N$

$\left|\frac{F}{N}\right| = .2947$ or less than $\mu_s = .30$ for (4)

(4)



centroids



① : 0.64kN at $x = 0.50m$

② : 0.32kN at $x = \frac{2}{3}m$

③ : 0.96kN at $x = 1.50m$

$\Sigma M_A = 0 = -0.64kN(0.50m) - 0.32kN(\frac{2}{3}m) - 0.96kN(1.50m) + F_{By}(2.50m)$

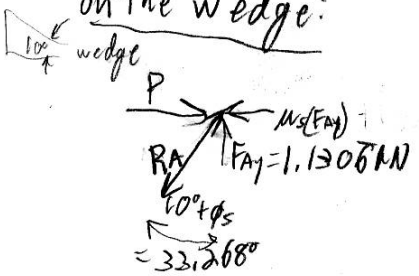
$F_{By} = .7893\,kN$

$\Sigma F_y = 0 = -.64kN - .32kN - .96kN + .7893kN + F_{Ay}$

$F_{Ay} = 1.1306\,kN$

(a) assuming no slippage of B: $\mu_s = 0.43 \rightarrow \phi_s = 23.268°$

on the wedge:



$\Sigma F_x = 0 = P - R_A \sin(33.268°) - 0.48618\,kN$

$P = 1.2280\,kN$

$\Sigma F_y = 0 = -R_A \cos(23.268°) + 1.1306\,kN$ ↑

$\rightarrow R_A = 1.3229kN$

(b) on the board: (for no slip) $\Sigma F_x = 0 = -F_{Bx} + R_A \sin(33.268°)$

$\rightarrow F_{Bx} = .67362kN$

$\left|\frac{F_{Bx}}{F_{By}}\right| = .853 > \mu_s = .43$

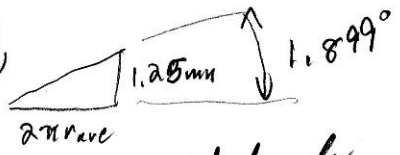
so slippage is expected (without constraint)

(5)

$r_{ave} = 6.00\,mm$

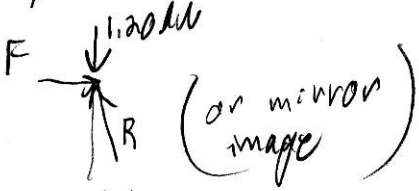
1.25mm lead (1 single thread, assumed)

for both A, B,



1.899° lead angle

$\mu_s = .15 \rightarrow \phi_s = 8.53°$ Then at A and B, advance requires



$\Sigma F_x = 0 = F - R\sin(10.43°)$

$R = \frac{F}{\sin(10.43°)}$

lead angle + μ_s = 10.43°

$\Sigma F_y = 0 = -1.20kN + R\cos(10.43°)$

$1.20kN \tan(10.43°) = F = 0.2209\,kN$

since each thread (A, B) requires F to advance (at thread radius)

Torque required $= 2F(6.00mm) =$ **$2.65N \cdot m = T$**