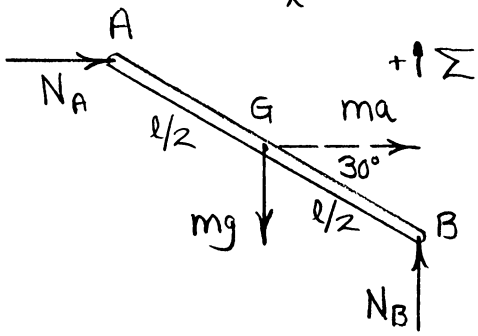
6/1 $\quad \overset{+}{\rightarrow} \Sigma F_x = ma : \quad N_A = ma \qquad (1)$

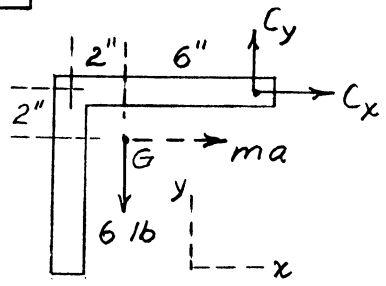


$+\uparrow \Sigma F_y = 0 \Rightarrow N_B = mg \qquad (2)$
(not needed)

$+\circlearrowleft \Sigma M_B = ma d : \quad N_A(\ell \sin 30°) - mg\left(\frac{\ell}{2}\cos 30°\right)$
$= ma\left(\frac{\ell}{2}\sin 30°\right) \qquad (3)$

Substitute (1) into (2): $\underline{a = g\sqrt{3}}$

6/2

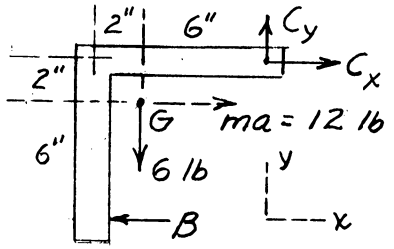


$\Sigma M_C = mad$

$6(6) = \frac{6}{g} a (2)$

$a = 3g$

6/3 $ma = \frac{6}{32.2}(2)(32.2) = 12 \text{ lb}$

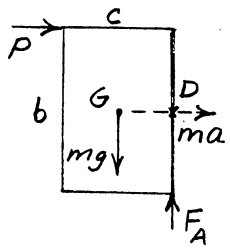


$\Sigma M_C = mad$

$6(6) - 8B = 12(2)$

$B = 1.5 \text{ lb}$

6/4 (a)

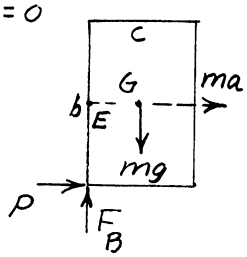


$\Sigma M_D = 0$

$P\frac{b}{2} - mg\frac{c}{2} = 0$

$P = mg\frac{c}{b}$

(b)

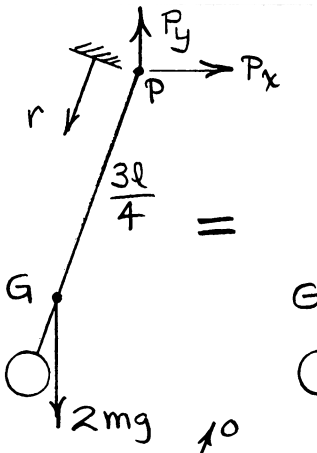


$\Sigma M_E = 0$

$mg\frac{c}{2} - P\frac{b}{2} = 0$

$P = mg\frac{c}{b}$

6/5



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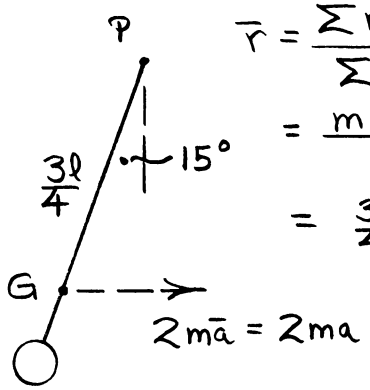


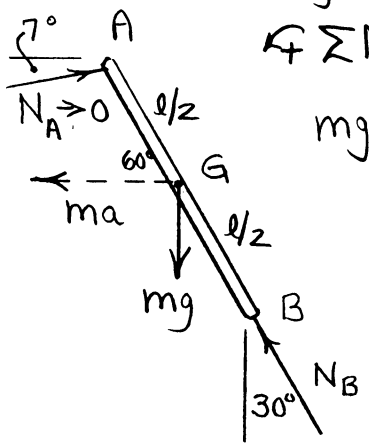
$$\bar{r} = \frac{\sum m_i r_i}{\sum m_i} = \frac{m\left(\frac{l}{2}\right) + m(l)}{m+m} = \frac{3}{4}l$$

$$\circlearrowleft + \quad \Sigma M_P = \bar{I}\alpha + m\bar{a}d \;:\; 2mg\left(\frac{3l}{4}\sin 15^\circ\right) = 2ma\left(\frac{3l}{4}\cos 15^\circ\right)$$

$$\Rightarrow a = g\tan 15^\circ = \underline{0.268g}$$

6/6

Tipping impends when $N_A \to 0$.

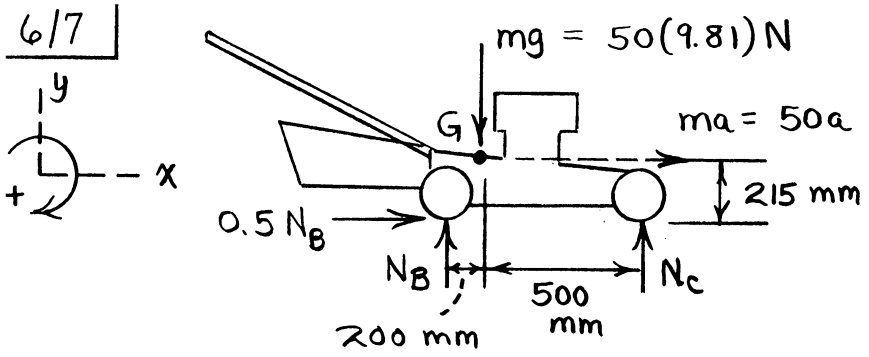


$\curvearrowleft \Sigma M_B = ma d$:

$$mg \frac{\ell}{2} \sin 30^\circ = ma \frac{\ell}{2} \cos 30^\circ$$

$$a = g \tan 30^\circ = 5.66 \text{ m/s}^2$$

6/7



$\Sigma F_x = ma$: $0.5 N_B = 50\,a$

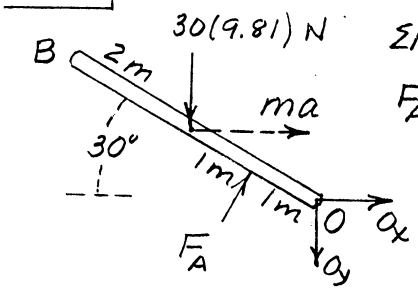
$\Sigma F_y = 0$: $N_B + N_C - 50(9.81) = 0$

$\Sigma M_B = mad$: $50(9.81)(0.2) - N_C(0.7) = 50a(0.215)$

Simultaneous solution :

$$\begin{cases} N_B = 414\ \text{N} \\ N_C = 76.6\ \text{N} \\ a = 4.14\ \text{m/s}^2 \end{cases}$$

6/8



$ma = 30(20) = 600\ N$

$\Sigma M_O = ma d_O$

$F_A(1) - 30(9.81)\,2\cos 30° = 600(2\sin 30°)$

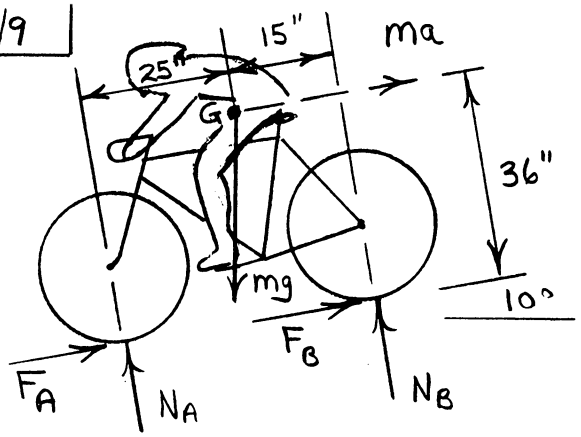
$F_A = 1110\ N$ or $F_A = 1.11\ kN$

$\Sigma F_x = ma_x$; $O_x + 1110\sin 30° = 600$, $O_x = 45\ N$

$\Sigma F_y = 0$; $O_y + 30(9.81) - 1110\cos 30° = 0$

$O_y = 667\ N$

6/9



Tipping at front wheel : $N_B, F_B \to 0$

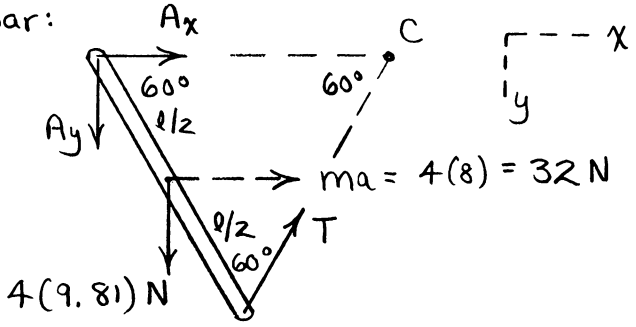
$+\circlearrowright \Sigma M_A = ma\,d$: $mg\,(25\cos 10° - 36\sin 10°)$

$= ma\,(36)$

Solve to obtain $a = \underline{0.510g}$ $(\underline{16.43\ ft/sec^2})$

6/10 | As a whole: $\Sigma F_x = ma$: $80 = (6+4)a$, $a = 8\ m/s^2$

Bar:



$\curvearrowleft \Sigma M_C = ma_d$: $A_y(2\ell\cos 60°) + 4(9.81)\frac{3\ell}{2}\cos 60°$

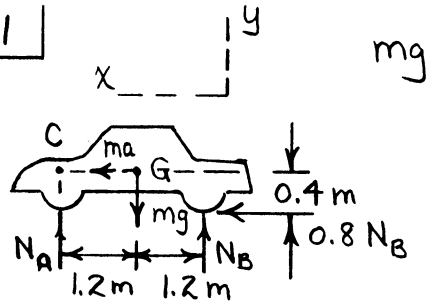
$= 32\left(\frac{\ell}{2}\sin 60°\right)$, $\underline{A_y = -15.57\ N}$

$\Sigma F_y = 0$: $-15.57 + 4(9.81) - T\sin 60° = 0$

$\underline{T = 27.3\ N}$

$\Sigma F_x = ma_x$: $A_x + 27.3\cos 60° = 32$, $\underline{A_x = 18.34\ N}$

6/11



$mg = 1650(9.81) = 16.19(10^3)\ N$

$\curvearrowright + \sum M_C = ma\,d = 0$: $N_B(2.4) - 0.8N_B(0.4) - 16.19(10^3)1.2 = 0$

$N_B = 9.34(10^3)\ N$ or $\underline{N_B = 9.34\ kN}$

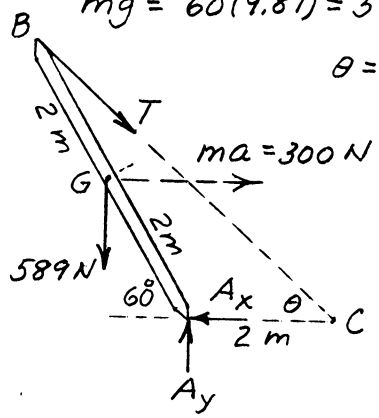
$\sum F_y = 0$: $N_A + 9.34(10^3) - 16.19(10^3) = 0$

$N_A = 6.85(10^3)\ N$ or $\underline{N_A = 6.85\ kN}$

6/12 $ma = 60(5) = 300\ N$

$mg = 60(9.81) = 589\ N$

$\theta = \tan^{-1}\dfrac{4\sin 60^\circ}{4\cos 60^\circ + 2} = 40.9^\circ$



$\Sigma M_A = ma\,d$; $(T\sin 40.9^\circ)(2) - 589(1) = 300(2\sin 60^\circ)$

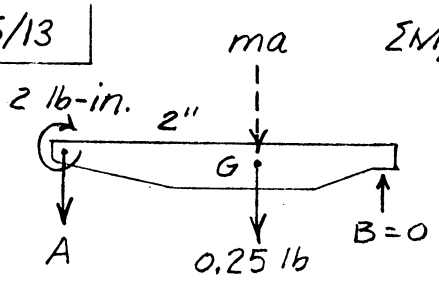
$T = 846\ N$

$\Sigma F_x = ma_x$; $846\cos 40.9^\circ - A_x = 300$, $A_x = 340\ N$

$\Sigma F_y = ma_y = 0$; $A_y - 589 - 846\sin 40.9^\circ = 0$, $A_y = 1143\ N$

$A = \sqrt{(340)^2 + (1143)^2} = \underline{1192\ N}$

6/13



$\Sigma M_A = ma\,d$

$2 + 0.25(2) = \dfrac{0.25}{32.2(12)}\,a(2)$

$a = 1932 \text{ in./sec}^2$

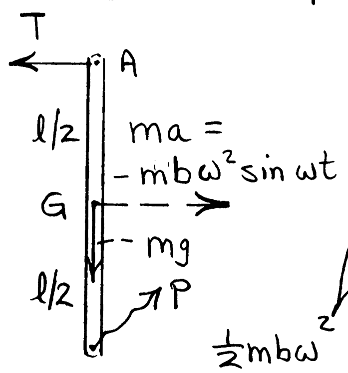
or $a = 161 \text{ ft/sec}^2$

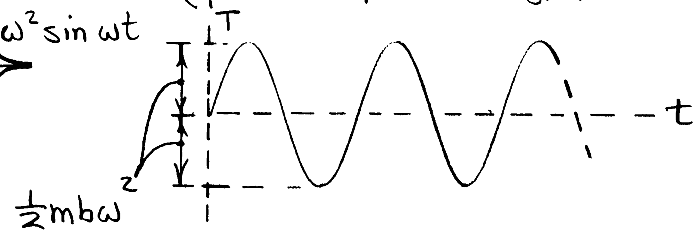
6/14

$+\circlearrowleft \Sigma M_P = m a d: \quad -T l = -m b \omega^2 \sin \omega t \left(\frac{l}{2}\right)$

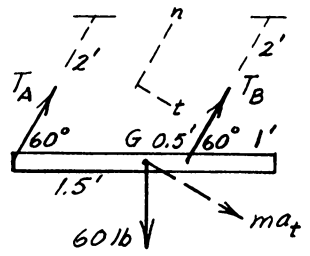
$\Rightarrow T = \frac{1}{2} m b \omega^2 \sin \omega t$

(positive T is tension in link)





6/15 | Curvilinear translation



$\Sigma F_t = ma_t$: $60 \cos 60° = \frac{60}{32.2} a_t$,

$a_t = 16.1$ ft/sec^2

$\alpha = a_t / r = 16.1/2 = \underline{8.05 \text{ rad/sec}^2}$

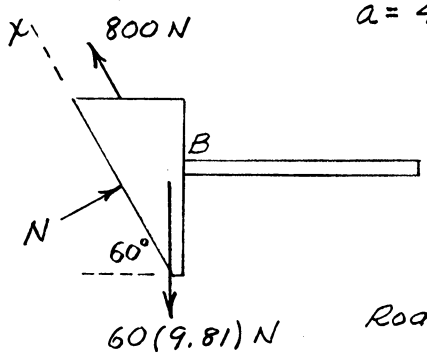
$\circlearrowleft + \Sigma M_G = 0$: $T_B \sin 60° \times 0.5 - T_A \sin 60° \times 1.5 = 0$, $T_A = \frac{1}{3} T_B$

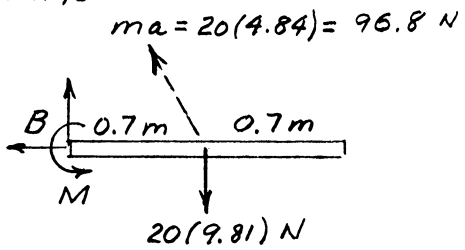
$\Sigma F_n = ma_n = 0$: $T_A + T_B - 60 \sin 60° = 0$, $T_A + T_B = 52.0$ lb

Combine & get $\underline{T_A = 12.99 \text{ lb}}$, $\underline{T_B = 39.0 \text{ lb}}$

6/16 $\Sigma F_x = ma_x$; $800 - 60(9.81)\sin 60^\circ = 60a$

$a = 4.84\ m/s^2$



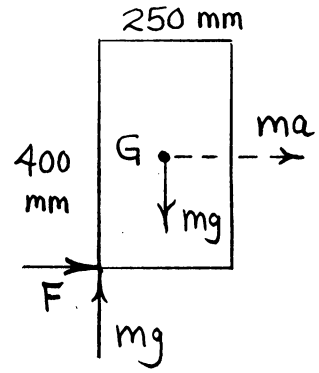


Rod: $\Sigma M_B = ma\,d$

$M - 20(9.81)0.7 = 96.8(0.7\sin 60^\circ)$

$M = 196.0\ N\cdot m$

6/17



$v = 1.2 + 0.9t^2$ m/s

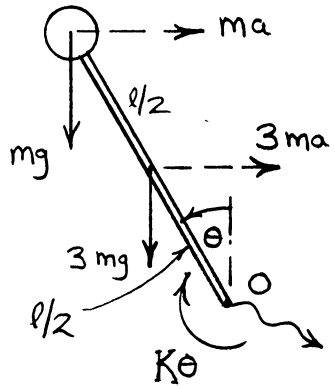
$a = \dot{v} = 1.8t$ m/s^2

$+\circlearrowright \Sigma M_A = ma\,d$:

$$mg\,\frac{250}{2} = m(1.8t)\left(\frac{400}{2}\right)$$

$$t = 3.41 \text{ s}$$

6/18



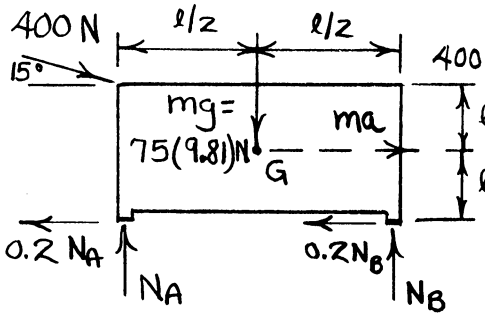
$\circlearrowleft_{+} \Sigma M_O = \Sigma ma_d$: $K\theta - 3mg\left(\frac{\ell}{2}\sin\theta\right) - mg(\ell\sin\theta) = 3ma\left(\frac{\ell}{2}\cos\theta\right) + ma(\ell\cos\theta)$

Simplify to

$$K\theta - \frac{5}{2}mg\ell\sin\theta = \frac{5}{2}ma\ell\cos\theta$$

With $m = 0.5$ kg, $\ell = 0.6$ m, $a = 2g$, and $\theta = 20°$, K is found to be $\underline{K = 46.8 \frac{N\cdot m}{rad}}$

6/19 | Static normals: $N_A = N_B = \frac{75(9.81)}{2} = 368\ \text{N}$



$400\cos 15° > 0.4[75(9.81) + 400\sin 15°]$ so slippage occurs

$+\rightarrow \Sigma F_x = ma$:

$$400\cos 15° - 0.2(N_A + N_B) = 75a \quad (1)$$

$+\uparrow \Sigma F_y = 0$: $N_A + N_B - 400\sin 15° - 75(9.81) = 0$ (2)

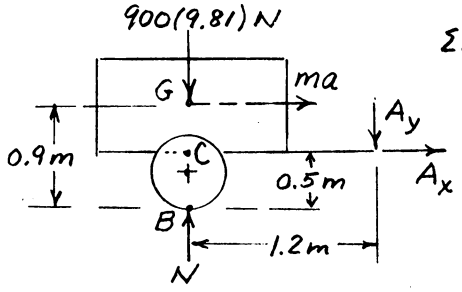
$\circlearrowright \Sigma M_A = ma\,d$: $75(9.81)\left(\frac{\ell}{2}\right) - N_B(\ell) + 400\cos 15°\left(\frac{\ell}{2}\right) = 75a\left(\ell/4\right)$ (3)

Solution of (1) - (3) : $N_A = 333$ N, $N_B = 506$ N

($a = 2.91\ \text{m/s}^2$)

$n_A = \frac{333 - 368}{368}(100\%) = \underline{-9.52\%}$; $n_B = \frac{506 - 368}{368}(100\%) = \underline{37.7\%}$

6/20 $v^2 = 2as$, $a = \frac{v^2}{2s} = \frac{(60/3.6)^2}{2(30)} = 4.63\ m/s^2$

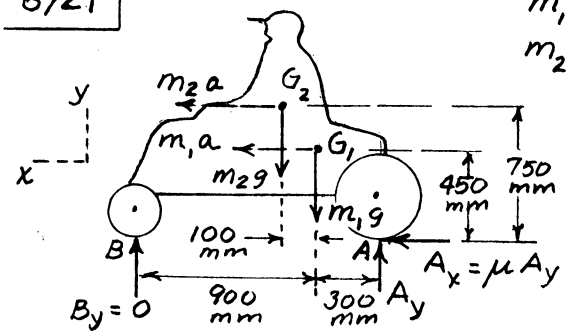


$\Sigma M_C = ma\bar{d}$;

$1.2A_y = 900(4.63)(0.9 - 0.5)$

$A_y = 1389\ N$

6/21



$m_1 g = 140(9.81) = 1373\ N$

$m_2 g = 90(9.81) = 883\ N$

$\Sigma F_y = 0$

$A_y - 1373 - 883 = 0$

$A_y = 2256\ N$

$\Sigma M_A = \Sigma ma d$; $883(0.4) + 1373(0.3) = 90a(0.75) + 140a(0.45)$

$765.2 = 130.5a$

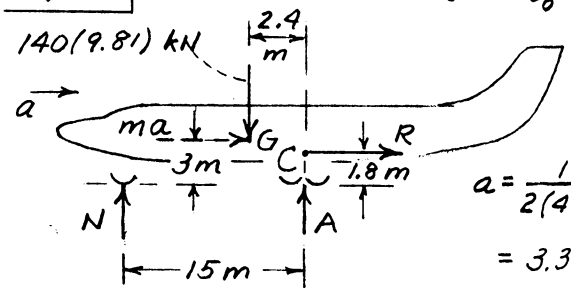
$a = 5.86\ m/s^2$

$\Sigma F_x = \Sigma m a_x$; $\mu(2256) = (140 + 90)5.86$

$\underline{\mu = 0.598}$

6/22

$v^2 = v_0^2 + 2as$



$$a = \frac{1}{2(425)}\left[(200)^2 - (60)^2\right]\frac{1}{(3.6)^2}$$

$$= 3.30 \text{ m/s}^2$$

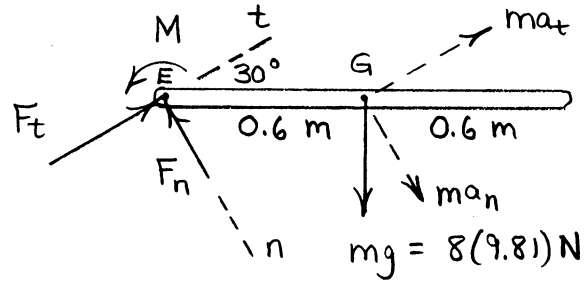
$\Sigma M_C = ma\,d$; $15N - 140(9.81)(2.4) = 140(3.30)(3 - 1.8)$

$N = 257$ kN

6/23 $a_E = a_A = a_C$

$(a_E)_n = r\omega^2 = 0.8(3)^2 = 7.2 \text{ m/s}^2$, $ma_n = 8(7.2) = 57.6 \text{ N}$

$(a_E)_t = r\alpha = 0.8(6) = 4.8 \text{ m/s}^2$, $ma_t = 8(4.8) = 38.4 \text{ N}$



$\curvearrowleft \Sigma M_E = \Sigma ma_d$: $M - 8(9.81)(0.6) = 38.4(0.6 \sin 30°) - 57.6(0.6 \cos 30°)$, $\underline{M = 28.7 \text{ N·m CCW}}$

$\Sigma F_t = ma_t$: $F_t - 8(9.81)\sin 30° = 38.4$, $F_t = 77.6 \text{ N}$

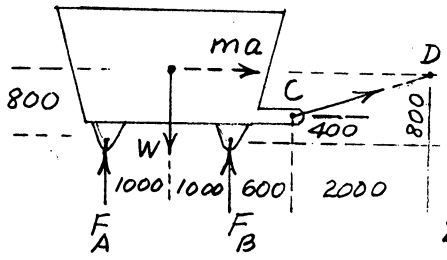
$\Sigma F_n = ma_n$: $-F_n + 8(9.81)\cos 30° = 57.6$, $F_n = 10.37 \text{ N}$

$F = \sqrt{F_t^2 + F_n^2} = \underline{78.3 \text{ N}}$

6/24 $ma = 2000(3) = 6000\ N$ or $6\ kN$

$W = mg = 2000(9.81) = 19\,620\ N$ or $19.62\ kN$

Dimensions in mm



$\Sigma M_C = ma\,d_C$

$F_A(2.6) + F_B(0.6) - 19.62(1.6) = 6(0.8 - 0.4)$

$2.6F_A + 0.6F_B = 33.79$ kN·m

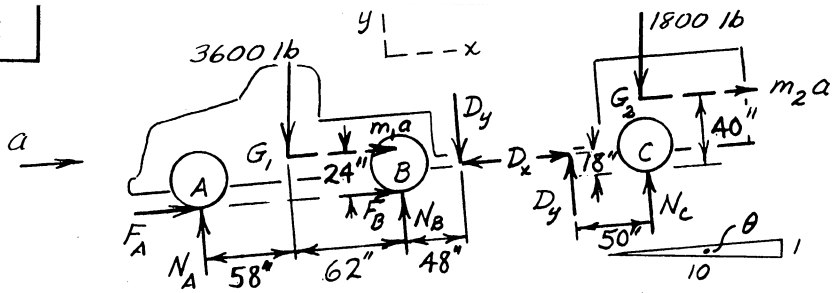
$\Sigma M_D = 0;\ F_A(4.6) + F_B(2.6) - 19.62(3.6) = 0$

$4.6F_A + 2.6F_B = 70.63$ kN·m

Solve simultaneously & get

$F_A = 11.37\ kN$, $F_B = 7.05\ kN$

6/25



For const. accel., $\theta = \tan^{-1}\frac{1}{10} = 5.71°$

$v^2 = v_0^2 + 2as$: $44^2 = 88^2 - 2a(360)$, $a = 8.07$ ft/sec^2 decel.

$m_1a = \frac{3600}{32.2} \times 8.07 = 902$ lb, $m_2a = \frac{1800}{32.2} \times 8.07 = 451$ lb

Trailer: $\Sigma F_x = ma_x$: $D_x - 1800\sin 5.71° = 451$, $\underline{D_x = 630 \text{ lb}}$

$\curvearrowleft \Sigma M_C = mad$: $50D_y + 630(18) - 1800\sin 5.71°(40) = 451(40)$, $\underline{D_y = 277 \text{ lb}}$

$\Sigma F_y = 0$: $N_C - 1800\cos 5.71° + 277 = 0$, $\underline{N_C = 1514 \text{ lb}}$

Truck:

$\curvearrowleft \Sigma M_A = mad$: $3600\cos 5.71° \times 58 - 3600\sin 5.71° \times 24 - 120N_B$
$+ 277(168) - 630(18) = 902(24)$

$\underline{N_B = 1773 \text{ lb}}$