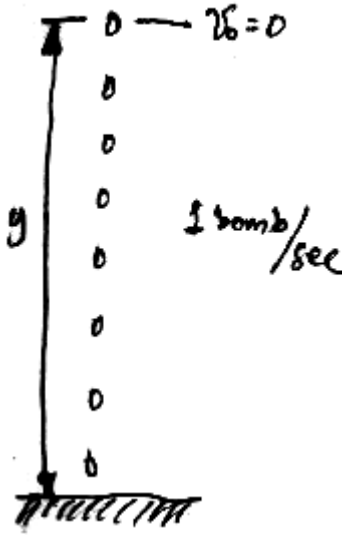
Answer Key

Physics and Engineering Mechanics 1

1



8 bombs in 8 seconds

$$y = \cancel{v_0 t} + \frac{1}{2} g t^2$$

$$y = \frac{1}{2}\left(9.81 \text{ m/s}^2\right)(8\text{s})^2$$

$$y = 313.92 \text{ m}$$

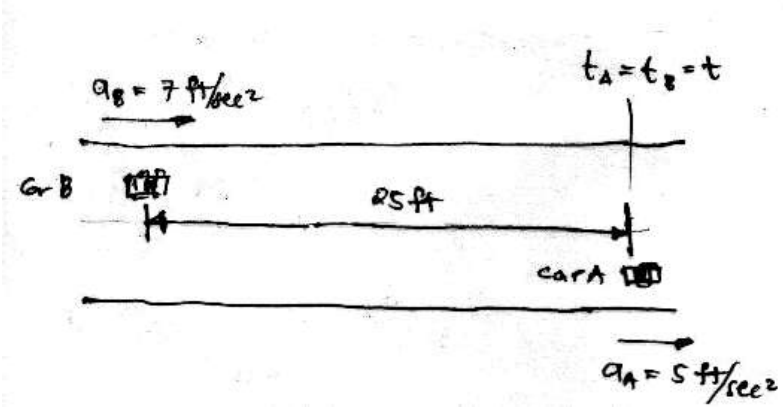
distance per bomb

$$y_8 = \frac{313.92 \text{ m}}{8 \text{ bombs}} = 39.24 \text{ m/bomb}$$

Hence; for 2 bombs

$$y_2 = \left(39.24 \frac{\text{m}}{\text{bomb}}\right)(2 \text{ bombs})$$

$$\boxed{y_2 = 78.48 \text{ m}}$$



$$S_B = S_A + 25\ ft$$

$$S_A = \cancel{V_0 t}^{0} + \frac{1}{2} a_A t^2$$

$$S_A = \frac{1}{2}\left(5\ ft/sec^2\right) t^2$$

$$S_A = 2.5\ t^2$$

$$S_B = \frac{1}{2}\left(7\ ft/sec^2\right) t^2$$

$$S_B = 3.5\ t^2$$

Subst;

$$3.5\ t^2 = 2.5\ t^2 + 25\ ft$$

$$\boxed{t = 5\ sec}$$

$$\omega_f = \omega_0 + \alpha t$$

$$0 = 850 \frac{\text{rev}}{\text{min}} + \alpha (1\text{min})$$

$$\alpha = -\left(850 \frac{\text{rev}}{\text{min}^2}\right)\left(\frac{1\text{min}}{60\text{sec}}\right)^2\left(\frac{2\pi\,\text{rad}}{1\text{rev}}\right)$$

$$\boxed{\alpha = -1.4835\ \text{rad/sec}^2}$$

Given: $S_A = 120$ miles $\quad S_B = 220$ miles

$t_A = 3.8$ hrs $\quad t_B = 5$ hrs

$$v_A = \frac{S_A}{t_A} = \frac{120 \text{ miles}}{3.8 \text{ hrs}} = 31.5789 \text{ mi/hr}$$

$$v_B = \frac{S_B}{t_B} = \frac{220 \text{ miles}}{5 \text{ hrs}} = 44 \text{ mi/hr}$$

Hence; average speed

$$v_{ave} = \frac{v_A + v_B}{2} = \frac{(31.5789 + 44) \text{ mi/hr}}{2}$$

$$v_{ave} = 37.7895 \text{ mi/hr}$$

train's top speed: $\left(55\frac{mi}{hr}\right)\left(\frac{5280\,ft}{1\,mi}\right)\left(\frac{1\,hr}{3600\,sec}\right) = 80.6667\,ft/sec$

$a = 6\,ft/sec^2$

from: $v_f^2 = \cancel{v_0^2}^{\,0} + 2as$

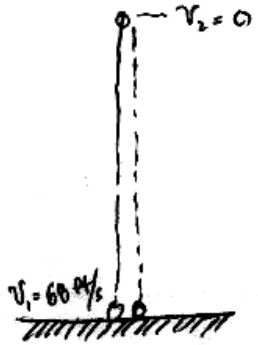
$(80.6667\,ft/sec)^2 = 2(6\,ft/sec^2)s$

$s = 542.2593\,ft$ 1 train stop

for 2 train stops

$s = 2(542.2593\,ft)$

$s = 1084.5185\,ft$



$$v_2 = v_0 - gt$$

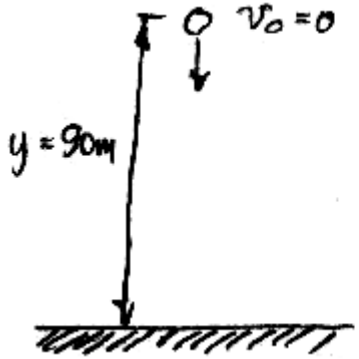
$$0 = 68\ \text{ft/sec} - (32.2\ \text{ft/sec}^2)\,t$$

$$t = 2.1118\ \text{sec}$$

total time

$$t = 2(2.1118\ \text{sec})$$

$$\boxed{t = 4.2236\ \text{sec}}$$



$$y = v_o t + \frac{1}{2} g t^2$$

$$90m = \frac{1}{2}\left(9.81\ m/s^2\right) t^2$$

$$t = 4.2835\ sec$$

$$S = v_0 t + \frac{1}{2} a t^2$$

$$= \left(15 \text{ ft/sec}\right)\left(2.6 \text{ sec}\right) + \frac{1}{2}\left(-4 \text{ ft/sec}^2\right)\left(2.6 \text{ sec}\right)^2$$

$$S = 25.48 \text{ ft}$$

$$v_0 = \left(67 \frac{mi}{hr}\right)\left(\frac{1 hr}{3600 sec}\right)\left(\frac{5280 ft}{1 mi}\right) = 98.2667 \frac{ft}{sec}$$

$$S = 387.4 \text{ ft}$$

$$v_f^2 = v_0^2 + 2as$$

$$0 = \left(98.2667 \frac{ft}{sec}\right)^2 + 2(a)(387.4 ft)$$

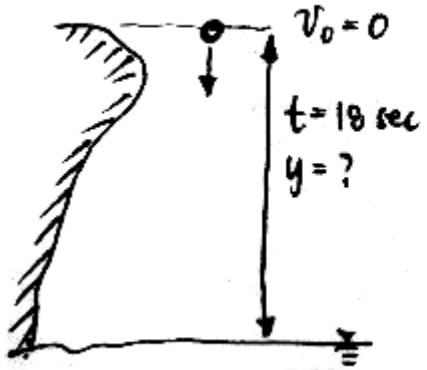
$$a = -12.4630 \frac{ft}{sec^2}$$

and,

$$v_f = v_0 + at$$

$$0 = 98.2667 \frac{ft}{sec} + \left(-12.4630 \frac{ft}{sec^2}\right) t$$

$$t = 7.8847 \text{ sec}$$



$$y = \cancel{V_0 t}^{0} + \frac{1}{2} g t^2$$

$$y = \frac{1}{2}\left(9.81 \text{ m/sec}^2\right)(18 \text{sec})^2$$

$$y = 1589.22 \text{ m}$$

$v_0 = 26\ m/s$

$v_f = 58\ m/s$

$t = 12\ sec$

$v_f = v_0 + at$

$58\ m/s = 26\ m/s + a(12\ sec)$

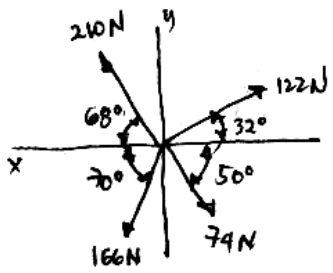
$a = 2.6667\ m/s^2$

$$W_T = (28 + 22 + 48 + 25 + 19 + 34)\,\text{lbs}$$

$$W_T = 171\ \text{lbs}$$

$$L = \frac{(3 + 4 + 6 + 7 + 10 + 13)\,\text{ft}}{6}$$

$$L = 7.1667\ \text{ft}$$



$$[R_x = \Sigma F_x] \rightarrow$$

$$122\cos 32° - 210\cos 68° - 166\cos 70° + 74\cos 50° = R_x$$

$$R_x = 15.5854\ N$$

$$[R_y = \Sigma F_y] \uparrow +$$

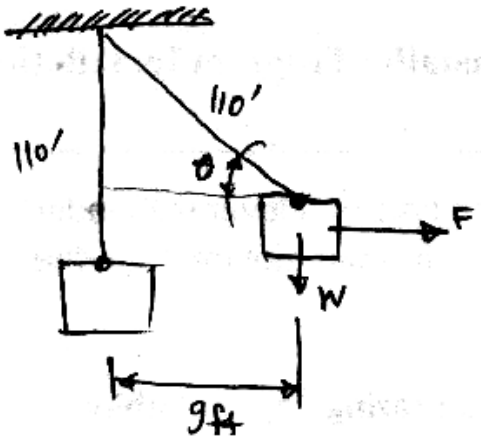
$$122\sin 32° + 210\sin 68° - 166\sin 70° - 74\sin 50° = R_y$$

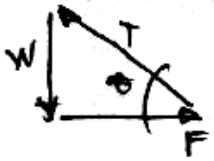
$$R_y = 46.6825\ N$$

Hence;

$$R = \sqrt{R_x^2 + R_y^2} = \sqrt{15.5854^2 + 46.6825^2}$$

$$R = 49.2154\ N$$





$$\cos\theta = \frac{9'}{110'}$$

$$\theta = 85.3070°$$

and; from force polygon

$$\tan\theta = \frac{W}{F}$$

$$\tan 85.3070° = \frac{17000\ lbs}{F}$$

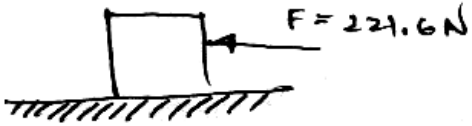
$$F = 1395.5435\ lbs$$

$[\Sigma F_y = 0]\ +\uparrow$

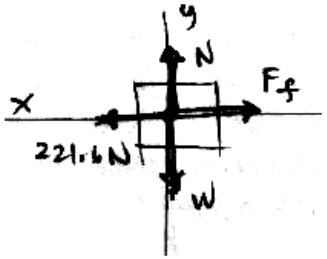
$T = W$

$= m\left(\frac{g_0}{g_c}\right) = 22\,kg\left(\frac{9.81\,m/s^2}{1\,\frac{kg-m}{N-s^2}}\right)$

$T = 245.25\,N$



FBD of Block



$[\Sigma F_x = 0] \rightarrow +$

$F_f = 221.6\ N$

$[\Sigma F_y = 0] \uparrow +$

$N = W$

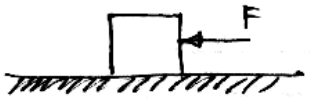
from:

$F_f = \mu N$

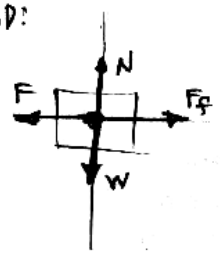
$221.6\ N = \mu (75.4\ kg)\left(\frac{9.81\ m/s^2}{1\ \frac{kg\text{-}m}{N\text{-}s^2}}\right)$

$\mu = 0.2996$

$\mu = 0.18$



FBD:



$[\Sigma F_x = 0] \rightarrow$ $[\Sigma F_y = 0] \uparrow +$

$F = F_f$ $N = W$

from; $F_f = \mu N$

$F = \mu W$

$= 0.18 (55\ lbs)$

$$F = (9.9\ lbs)\left(\frac{1\ kg}{2.2\ lbs}\right)\left(\frac{9.81\ m/s^2}{1\ \frac{kg-m}{N-s^2}}\right)$$

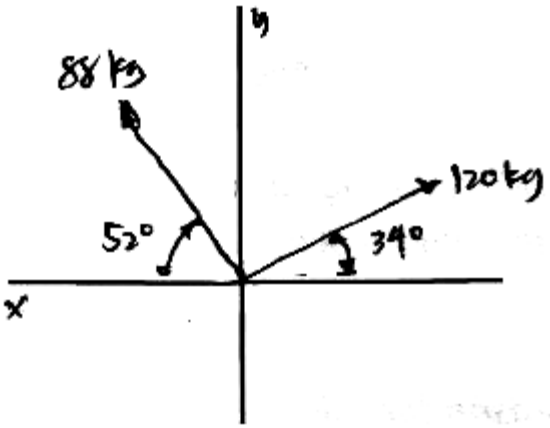
$F = 44.145\ N$

$F_1 = 18\ kg$

$F_2 = 62\ kg$

$$R = \sqrt{18^2 + 62^2}$$

$$R = 64.56\ kg$$



$[\Sigma F_y = R_y]\ +\uparrow$

$R_y = 120\text{ kg} \sin 34° + 88\text{ kg} \sin 52°$

$R_y = 136.4481\text{ kg}$

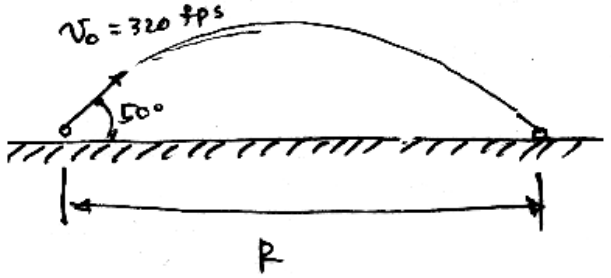
$[\Sigma F_x = R_x]\ \pm\rightarrow$

$R_x = 120\text{ kg} \cos 34° - 88\text{ kg} \cos 52°$

$R_x = 45.3063\text{ kg}$

$R = \sqrt{R_x^2 + R_y^2} = \sqrt{45.3063^2 + 136.4481^2}$

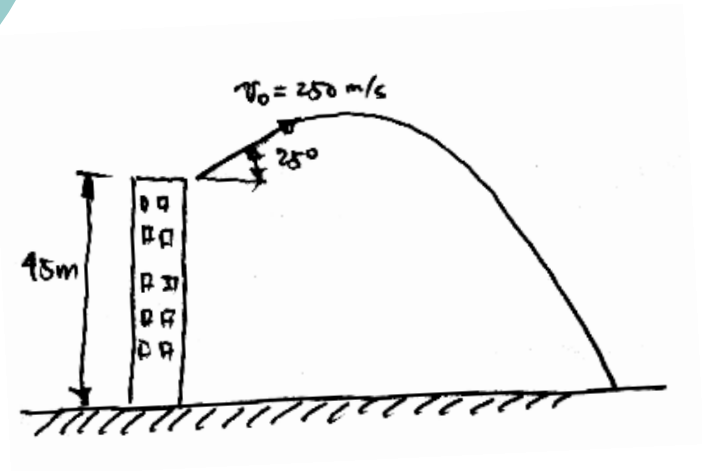
$R = 143.7732\text{ kg}$



$$R = \frac{v_o^2 \sin 2\theta}{g} = \frac{(320\ \text{ft/sec})^2 \sin 2(50°)}{(32.2\ \text{ft/sec}^2)}$$

$$R = (3131.8110\ \text{ft})\left(\frac{1\ \text{yd}}{3\ \text{ft}}\right)$$

$$R = 1043.937\ \text{yd}$$



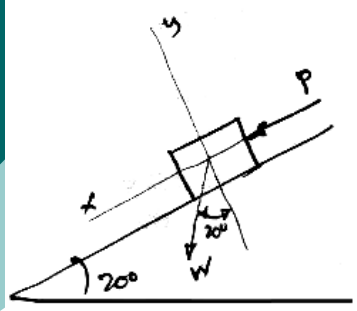
$$y = v_{oy}t - \frac{1}{2}gt^2$$

$$-45\text{m} = (250\text{ m/s})\sin 25\,t - \frac{1}{2}(9.81\text{ m/s}^2)t^2$$

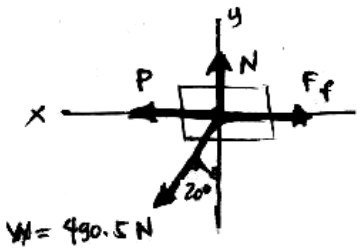
$$4.905t^2 - 105.6546t + 45 = 0$$

$$t_1 = 21.1055 \text{ sec}$$

$$t_2 = 0.4347 \text{ sec (disregard)}$$



FBD of block:



$[\Sigma F_x = 0] \rightarrow +$

$-P - W\sin 20° + F_f = 0$

$F_f = P + W\sin 20°$

$[\Sigma F_y = 0] \uparrow +$

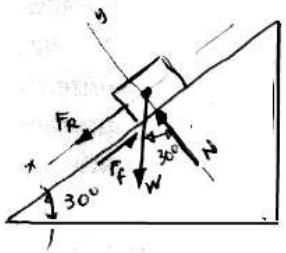
$N = W\cos 20°$

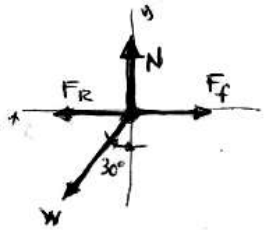
from: $F_f = \mu N$

$P + W\sin 20° = 0.60(W\cos 20°)$

$P = 0.60\, W\cos 20° - W\sin 20°$

$\boxed{P = 108.7907\ N}$





$[\Sigma F_x = 0] \xrightarrow{+}$

$F_f - F_R - W\cos 60° = 0$

$F_f = fN$

$= (0.28)(W\sin\theta)$

$= (0.28)(30\text{ kg})\left(\frac{9.81\text{ m/s}^2}{1\ \frac{\text{kg-m}}{\text{N-s}^2}}\right)\sin 60°$

$F_f = 71.3640\text{ N}$

$W = m\left(\frac{g_0}{g_c}\right) = (30\text{ kg})\left(\frac{9.81\text{ m/s}^2}{1\ \frac{\text{kg-m}}{\text{N-s}^2}}\right) = 294.3\text{ N}$

Subs in;

$71.3640\text{ N} - F_R - (294.3\text{ N})\cos 60° = 0$

$F_R = 75.786\text{ N}$

and; From Newton's second Law of motion

$F = m\left(\frac{a_0}{g_c}\right)$

$75.786\text{ N} = (30\text{ kg})\left(\frac{a_0}{1\ \frac{\text{kg-m}}{\text{N-s}^2}}\right)$

$a_0 = 2.5262\text{ m/s}^2$

Hence;

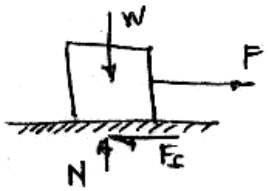
$v_f^2 = 2as = 2(2.5262\text{ m/s}^2)(15\text{ m})$

$v_f = 8.7055\text{ m/s}$

Given: $m = 120\ kg$

$d = 85\ m$

$f = 0.28$



$$F_f = fN$$

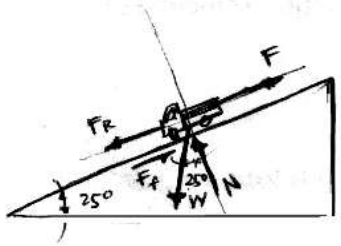
$$= (0.28)(120\ kg)\left(\frac{9.81\ m/s^2}{1\ \frac{kg-m}{N-s^2}}\right)$$

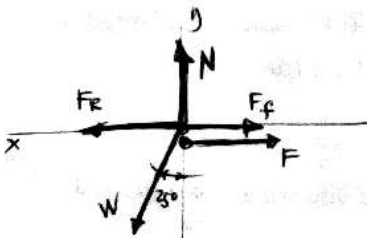
$$F_f = 329.616\ N$$

$$Work = F \cdot d = (329.616\ N)(85\ m)$$

$$Work = 28017.36\ J$$

$$\boxed{Work = 28.0174\ kJ}$$





$[\Sigma F_x = 0] \xrightarrow{+}$

$F_f - F_R - W\cos 65^\circ + F = 0$

$F_f = f N$

$= (0.12)(5000\,\text{lbs})\left(\frac{32.2\ \text{ft/sec}^2}{32.2\ \frac{\text{lb-ft}}{\text{lbf-sec}^2}}\right)\sin 65^\circ$

$F_f = 543.7847\ \text{lbs}$

$W = m\left(\frac{g_0}{g_c}\right) = 5000\,\text{lbs}\left(\frac{32.2\ \text{ft/sec}^2}{32.2\ \frac{\text{lb-ft}}{\text{lbf-sec}^2}}\right) = 5000\ \text{lbf}$

$F_R = m\left(\frac{g_0}{g_c}\right) = (5000\ \text{lbs})\left(\frac{8\ \text{ft/sec}^2}{32.2\ \frac{\text{lb-ft}}{\text{lbf-sec}^2}}\right)$

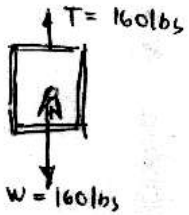
$F_R = 1242.2360\ \text{lbs}$

Hence; substituting

$543.7847\,\text{lbs} - 1242.2360\,\text{lbs} - 5000\,\text{lbf}\cos 65^\circ + F = 0$

$F = 2811.5426\ \text{lbs}$

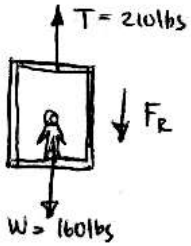
when elevator at rest



$[\Sigma F_y = 0]\ \uparrow +$

$W = T$

when elevator moving upwards



$[\Sigma F_y = 0]\ \uparrow +$

$-F_R - W + T = 0$

$-F_R - 160\,lbs + 210\,lbs = 0$

$F_R = 50\,lbs$

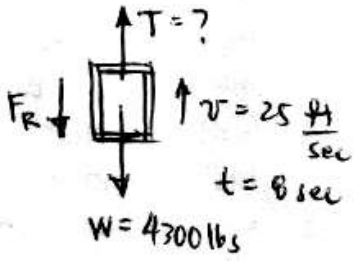
then; from 2nd law of motion

$$F_R = m\left(\frac{a_0}{a_c}\right)$$

$$50\,lbs = 160\,lbs\left(\frac{a_0}{32.2\ \frac{lb\text{-}ft}{lbf\text{-}sec^2}}\right)$$

$$a_0 = 10.0625\ ft/sec^2$$

GIVEN:



$[\Sigma F_y = 0]\ \uparrow +$

$T = W + F_R$

$v_f = v_0 + at$

$25\ ft/sec = a(8\ sec)$

$a = 3.125\ ft/sec^2$

From 2nd law of motion

$$F_R = m\left(\frac{a_0}{a_c}\right)$$

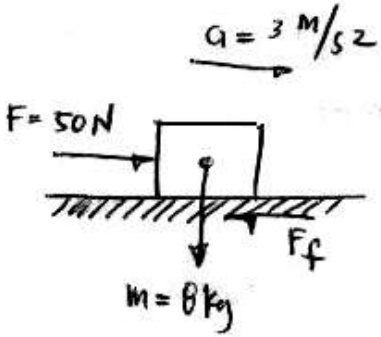
$$= 4300\ lbs\left(\frac{3.125\ ft/sec^2}{32.2\ \frac{lb-ft}{lb-sec^2}}\right)$$

$F_R = 417.3137\ lbs$

Subst;

$T = 4300\ lbs + 417.3137\ lbs$

$T = 4717.3137\ lbs$



$$\Sigma F = m\left(\frac{a_0}{a_c}\right)$$

$$F - F_f = m\left(\frac{a_0}{a_c}\right)$$

$$50N - F_f = 8kg\left(\frac{3\,m/s^2}{1\,\frac{kg-m}{N-s^2}}\right)$$

$$\boxed{F_f = 26\,N}$$

$$W = m\left(\frac{g_0}{g_c}\right)$$

$$= 55\ lb_m\left(\frac{5.32\ ft/sec^2}{32.2\ \frac{lb-ft}{lb_f-sec^2}}\right)$$

$$W = 9.0870\ lbs$$

Given: $m = (85 \text{ slugs})\left(\frac{32.2 \text{ lbm}}{1 \text{ slug}}\right) = 2737 \text{ lbm}$

$a = 10 \text{ ft/sec}^2$

from Newton's 2nd Law of Motion

$$f = m\left(\frac{a_0}{a_c}\right)$$

$$= 2737 \text{ lbm}\left(\frac{10 \text{ ft/sec}^2}{32.2 \frac{\text{lb-ft}}{\text{lf-sec}^2}}\right)$$

$$f = 850 \text{ lbf}$$