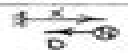
3/29 

(Neglect weight for now)

$\Sigma F_x = ma_x$: $-D = -C_D \frac{1}{2}\rho v^2 S = mv\frac{dv}{dx}$

$\int_0^x (-C_D \frac{1}{2}\rho S)\,dx = m\int_{v_0}^{v}\frac{dv}{v}$

$\Rightarrow v = v_0 e^{(-\frac{1}{2}C_D\rho S x/m)}$

$= v_0 e^{(-\frac{1}{2}(0.3)(\frac{0.07530}{32.2})(\pi)(\frac{9.125/24}{12})^2 x/(\frac{5.125}{16\cdot 32.2})}$

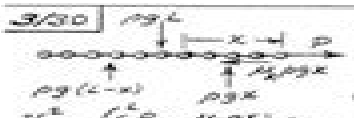
$\underline{v = v_0 e^{-1.623(10^{-3})x}}$

For $v_0 = 90$ mi/hr and $x = 60$ ft: $\underline{v = 81.7 \text{ mi/hr}}$

Comment on y-motion. Assume $v = 90$ mi/hr = constant. Time t to plate is

$t = \frac{60}{90(5280/3600)} = 0.455$ sec

$v_y = v_{y_0} - gt = -32.2(0.455) = -14.64$ ft/sec, which would not appreciably change $v = \sqrt{v_x^2 + v_y^2}$.

3/30 

$\Sigma F_x = ma_x$;

$P - \mu_k \rho g x = \rho L a_x$

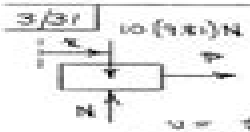
$\int_0^v v\,dv = \int_0^L a_x\,dx$

$\frac{v^2}{2} = \int_0^L (\frac{P}{\rho L} - \frac{\mu_k g x}{L})dx = \frac{P}{\rho} - \frac{\mu_k g L}{2}$, $\underline{v = \sqrt{\frac{2P}{\rho} - \mu_k g L}}$

From $\frac{v^2}{2} = \int_0^x (\frac{P}{\rho L} - \frac{\mu_k g x}{L})dx$, we obtain

$v(x) = \sqrt{2\frac{x}{L}(\frac{P}{\rho} - \mu_k g \frac{x}{L})}$

Note that $v(L) \geq 0$ if $\underline{P \geq \mu_k \rho g \frac{L}{2} = P_{min}}$

3/31 

$\Sigma F_x = ma_x$: $P = 10a_x$

$\frac{P}{10} = \frac{dv}{dt}$, $v = \int_0^t \frac{P}{10}dt$

For $P_1 = 10t$:

$v = t^2/2$, $s = t^3/6$

At $t = 5$ s, $\underline{v = 12.5 \text{ m/s}}$, $\underline{s = 20.8 \text{ m}}$

For $P_2 = kt^2$: $50 = k(5)^2$, $k = 2$ N/s²

So $P_2 = 2t^2$

$v = \int_0^t \frac{2t^2}{10}dt = \frac{t^3}{15}$, $s = t^4/60$

At $t = 5$ s, $\underline{v = 8.33 \text{ m/s}}$, $\underline{s = 10.42 \text{ m}}$

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$\theta = \tan^{-1}\frac{250}{2000} = 7.13°$

$v_B^2 - v_A^2 = 2a_x(s_B - s_A)$:

$(\frac{200}{3.6})^2 - (\frac{300}{3.6})^2 = 2a_x(\frac{2000}{\cos 7.13°})$, $a_x = -0.957$ m/s²

$\Sigma F_x = ma_x$: $-D + 200(10^3)(9.81)\sin 7.13° = 200(10^3)(-0.957)$, $\underline{D = 435 \text{ kN}}$

$\Sigma F_y = 0$: $L - 200(10^3)(9.81)\cos 7.13° = 0$

$\underline{L = 1.947 \text{ MN}}$

The net aerodynamic force is then

$R = \sqrt{L^2 + D^2} = \sqrt{1.947^2 + 0.435^2} = \underline{1.995 \text{ MN}}$

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FBD of cone during penetration:

$\Sigma F_x = ma_x$: $mg - kx^2 = mv\frac{dv}{dx}$

$\int_0^d (g - \frac{k}{m}x^2)dx = \int_{v_0}^0 v\,dv$

$gd - \frac{k}{3m}d^3 = -\frac{v_0^2}{2}$, where $v_0 = \sqrt{2gh}$

$\therefore \underline{k = \frac{3mg}{d^3}(h+d)}$

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Accel. down: $\Sigma F_y = ma_y$: $-mg + N = -ma$, $N = m(g-a)$

$\Sigma F_x = ma_x$: $-\mu_k m(g-a) = ma_x$, $a_x = -\mu_k(g-a)$

Accel. up: $\Sigma F_y = ma_y$: $N - mg = ma$, $N = m(g+a)$

$\Sigma F_x = ma_x$: $-\mu_k m(g+a) = ma_x$, $a_x = -\mu_k(g+a)$

$v^2 = v_0^2 + 2as$: Down: $0 = v^2 - 2\mu_k(g-a)s_1$

Up: $0 = v^2 - 2\mu_k(g+a)s_2$

Eliminate v^2 & get $(g-a)s_1 = (g+a)s_2$,

$\underline{a = g\frac{s_1 - s_2}{s_1 + s_2}}$

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