3-23 Vierck $\Delta_{st} = .375_{in} \times \frac{1ft}{12in}$, $W = 12lb \Rightarrow m = \frac{W}{g} = \frac{W}{32.2}$, $c = 0.15 \frac{lb\text{-}s}{in} \times \frac{12in}{ft}$

ζ? ω_n? ω_d?

$$\omega_n = \sqrt{\frac{g}{\Delta_{st}}} \Rightarrow C_{cr} = 2m\omega_n \Rightarrow \zeta = \frac{c}{C_{cr}} < 1, \quad \omega_d = \omega_n\sqrt{1-\zeta^2}$$

3-24 δ? x_0/x_1?

$$\delta = \frac{2\pi\zeta}{\sqrt{1-\zeta^2}} \Rightarrow \delta = \frac{1}{n}\ln\left(\frac{x_0}{x_1}\right) \Rightarrow \delta = \ln\left(\frac{x_0}{x_1}\right) \Rightarrow e^{\delta} = \frac{x_0}{x_1} = \frac{x_1}{x_2} = \dots = \frac{x_n}{x_{n+1}}$$

3-28 15 cycles 80% reduction $\Rightarrow x_{15} = 0.2x_0$, $C_{cr} = 70 \frac{N\text{-}s}{m}$

c?

$$\delta = \frac{1}{n}\ln\left(\frac{x_0}{x_n}\right) = \frac{1}{15}\ln\left(\frac{x_0}{0.2x_0}\right) = \frac{1}{15}\ln 5; \quad \delta = \frac{2\pi\zeta}{\sqrt{1-\zeta^2}} \Rightarrow \zeta = \frac{\delta}{\sqrt{4\pi^2+\delta^2}}$$

$$\Rightarrow c = C_{cr}\cdot\zeta$$

3-29 $W = 7.72lb \Rightarrow m = \frac{W}{g}$, $k = 5\frac{lb}{in} = 60\frac{lb}{ft}$, $c = 0.125 \frac{lb\text{-}s}{in} \times \frac{12in}{ft} = 1.5 \frac{lb\text{-}s}{ft}$

$$\omega_n = \sqrt{\frac{k}{m}} \Rightarrow C_{cr} = 2m\omega_n \Rightarrow \zeta = \frac{c}{C_{cr}} \begin{cases} \text{O.D.} & \zeta > 1 \\ \text{C.D.} & \zeta = 1 \\ \text{U.D.} & 0 < \zeta < 1 \end{cases}$$

x_0, $v_0 = 0$

$\zeta > 1$ $x(t) = C_1 e^{s_1 t} + C_2 e^{s_2 t}$ $s_1, s_2 = -\zeta\omega_n \pm \sqrt{\zeta^2 - 1}\cdot\omega_n$

$x(t^*) = x_0 \cdot$ number

$\zeta = 1$ $x(t) = (C_1 + C_2 t)e^{-\omega_n t}$ $t^* = \frac{1}{\omega_n} - \frac{C_1}{C_2}$

$x(t') = x_0 \cdot$ number