1. (a) $$\frac{C(s)}{R(s)} = \frac{(s+1)\frac{10}{s^2}}{1 + \frac{10(s+1)}{s^2}}$$

$$\boxed{\frac{C(s)}{R(s)} = \frac{10\,(s+1)}{s^2 + 10s + 10}}$$

(b) poles: $\boxed{s = -5 \pm \sqrt{15}}$, $= \begin{matrix}-8.9\\-1.1\end{matrix}$

step response

$$C(s) = \frac{1}{s}\left\{ \frac{10\,(s+1)}{\{s+5+\sqrt{15}\}(s+5-\sqrt{15})} \right\}$$

$$c(t) = e^{st}C(s)s\Big|_{s=0} + e^{st}C(s)\{s+5+\sqrt{15}\}\Big|_{s=-5-\sqrt{15}} + e^{st}C(s)\{s+5-\sqrt{15}\}\Big|_{s=-5+\sqrt{15}}$$

$$= 1 + \left[\frac{10}{-5-\sqrt{15}}\right]\frac{(-5-\sqrt{15}+1)}{(-2\sqrt{15})} e^{-(5+\sqrt{15})t} + \left[\frac{10}{-5+\sqrt{15}}\right]\frac{(-5+\sqrt{15}+1)}{(2\sqrt{15})} e^{(-5+\sqrt{15})t}$$

$$= 1 - 1.1\cancel{45}\,e^{-8.9t} + .1\cancel{45}\,e^{-1.1t}$$

$$\boxed{c(t) = 1 - 1.145\left\{e^{-8.9t} - e^{-1.1t}\right\} \quad t > 0}$$

B 4-13

$$\frac{C(s)}{R(s)} = \frac{G\frac{1}{s}}{1+G\frac{1}{s}} \qquad G = \frac{16}{s+0.8+16k}$$

$$= \frac{16}{s(s+0.8+16k)+16} = \frac{16}{s^2+(0.8+16k)s+16}$$

$$2\omega_n\zeta = 0.8+16k \Rightarrow 16k = 2(4)(0.5)-0.8 \Rightarrow \boxed{k=0.2}$$

$$\omega_n^2 = 16 \Rightarrow \boxed{\omega_n = 4}$$

$$\boxed{\zeta = 0.5}$$

$$t_r = \frac{\pi - \tan^{-1}\left(+\frac{\sqrt{1-\zeta^2}}{\zeta}\right)}{\omega_d} = \frac{\pi - \tan^{-1}\left(+\frac{\sqrt{\frac{3}{4}}}{1/2}\right)}{4\sqrt{\frac{3}{4}}} = \cancel{t\,20.604}$$

$$t_p = \frac{\pi}{\omega_d} = \frac{\pi}{\omega_n\sqrt{1-\zeta^2}} = \frac{\pi}{4\sqrt{\frac{3}{4}}} = 0.906$$

$$M_p = e^{-\frac{\zeta}{\sqrt{1-\zeta^2}}\pi} = e^{-\frac{1}{2}\sqrt{\frac{4}{3}}\pi} = 0.16$$

$$2\% : t_s = \frac{4}{\zeta\omega_n} = \frac{4}{4(\frac{1}{2})} = 2$$