HW 4)

4.11 (a) $\frac{W+D(R-Y)-KY}{s^2} = Y$

$E(s) = R(s) - Y(s)$

$Y + \frac{DY}{s^2} + \frac{KY}{s^2} = \frac{W - KY + DR}{s^2}$

$Y = \frac{DR+W}{s^2+Ds+K}$

$= \frac{-Ds-s^2+Ds+K}{s^2+Ds+K} R(s)$

$= \frac{s^2+K}{s^2+Ds+K} R(s)$

$\lim_{s\to 0} E(s) =$ ~~K~~ constant $\rightarrow$ $D(s)$ = pole @ (0,0)

(b) $Y(s) = \frac{W(s)}{s^2+Ds+K}$

$\lim_{s\to 0} \frac{1}{s^\ell} \cdot \frac{1}{s^2+Ds+K} = 0$

if $\lim_{s\to 0} s^{\ell-1} D(s) = 0$

$\ell = 1$ $D(s)$ has pole @ o.p. system rejects disturbances.

4.26) a) $m\ddot{x} = K_a u - Dx$

$\mathcal{L}\{m\ddot{x} = K_a u - Dv\}$

$\frac{V}{U} = \frac{K_a}{ms+D} = \frac{0.01}{s+0.01}$

b) $E(s) = V_d - V = V_d - \frac{k_p}{s+0.52} V_d$

$\frac{1 + \frac{k_p}{s+0.52}}{}$

$+ \frac{0.05 \frac{1}{s+0.52}}{1 + \frac{k_p}{s+0.52}} G(s)$

c) 0 @ s.s. error for step input

$\lim_{s\to 0} \left(\frac{(s+0.52) V_d - 0.05 G}{s+0.52+k_p} \right) \frac{z}{3} = \frac{-0.05}{0.52+k_p}$

d) $\zeta = 1 \rightarrow \omega_n = 0.01 \rightarrow k_i = 0.0001$

$\left| \frac{-0.1}{0.52+k_p} \right| < 1 \rightarrow$ ~~$k_p < 0.08$~~

$k_p > 0.08$

9.29)

(a) TF.

$$\frac{Y}{W} = \frac{\frac{1}{\zeta s+b}}{1+\frac{1}{\zeta s+b}\cdot\frac{10k_p}{0.5s+1}} \qquad b=1,\ \zeta=0.1$$

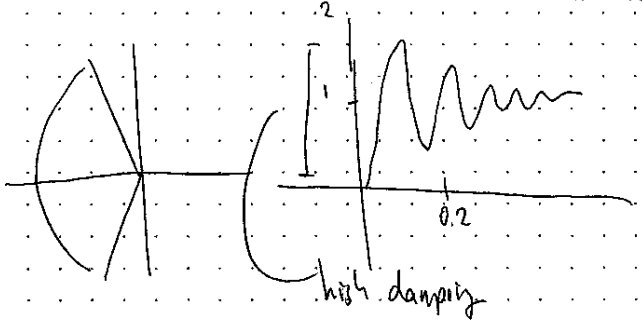
$$e_{ss}(\text{step}) = \lim_{s\to 0} \frac{Y}{W} = \frac{1}{1+10k_p}$$

$$e_{ss} \le 0.01 \quad k_p \ge 9.9 \quad \boxed{k_p = 10}$$

(b)

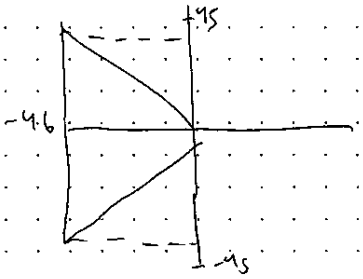
$$\frac{Y}{R} = \frac{\frac{10k_p \cdot 1}{(0.5s+1)(\zeta s+1)}}{1+\frac{10k_p}{(\zeta s+1)(0.5s+1)}} = \frac{2000}{s^2+12s+2020} \rightarrow \omega_n^2$$

$$\omega_n = 45 \qquad \zeta = \frac{12}{2\cdot 45} = 0.13$$



(c) $t_s \le 0.1 \rightarrow \sigma \ge 46$

$M_p \le 0.05 \rightarrow \zeta \ge 0.7$



(d) + derivative feedback

$$\frac{Y}{R} = \frac{10k_p \cdot 1}{0.5s+1)(\zeta s+1)} \Big/ 1 + \frac{(0k_i(k_p s+1)}{(0.5s+1)(\zeta s+1)}$$

$$= \frac{200k_p}{s^2+(12+200k_p k_p)s+20(1+10k_p)}$$

Any values of k_i and k_p can create all values of ζ and ω_n

(c) $\frac{Y}{W} = \frac{\frac{1}{5s+5}}{1+\frac{1}{5s+5}\cdot\frac{10k_p(k_0s+1)}{0.5s+1}} = \frac{20(0.5s+1)}{s^2+(12+200k_pk_0)s+5(1+10k_p)}$

$e_{ss}(\text{step}) = \frac{1}{1+10k_p}$

add integrator $k_p \to k_p + \frac{k_1}{s}$

$\frac{Y}{W} = \frac{20(0.5s+1)}{s^3+(12+200k_pk_0)s^2+(20+1100k_p+200k_1k_0)s+200k_1}$

$e_{ss}(\text{step}) = 0$