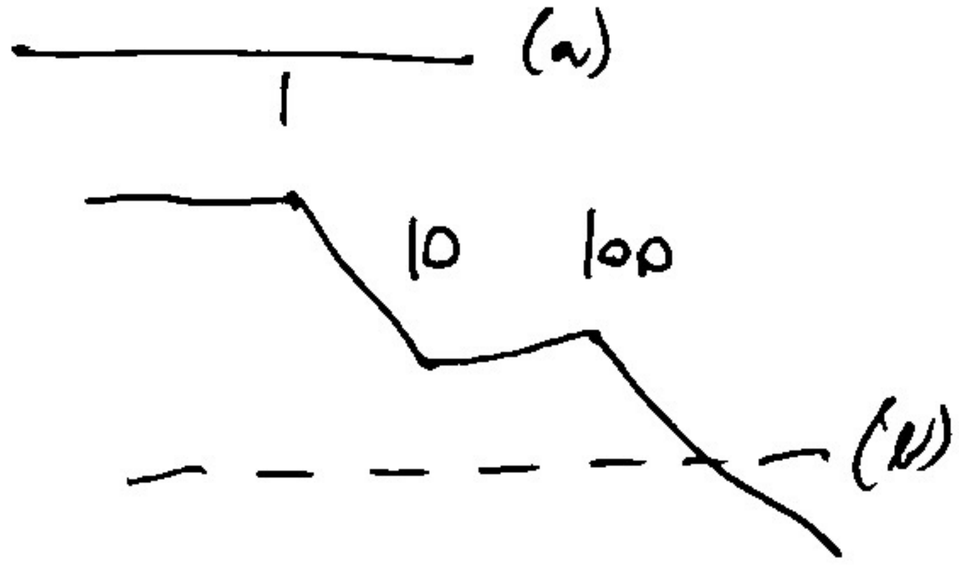
1)



(a)

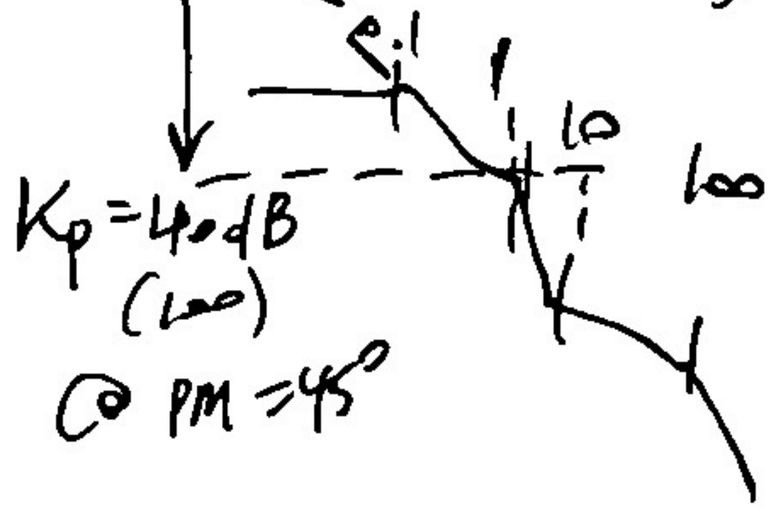
$$\frac{s+10}{(s+1)(s+100)}$$

$$= \frac{s+10}{s^2+101s+100}$$

(b) $K_p = 1000$; $\dfrac{1000\,(s+10)}{(s+1)(s+100)}$:

DC gain = 100 ⇒ 1% error
PM = 90°
BW = 1000

(c) $\dfrac{K_p\,(s+10)}{(10s+1)(s+1)(s+100)}$



DC gain = 1 ⇒ 10% error
PM = 45°
BW = 1

(b) K_i removing pole @ 0.1

$$K_p + \frac{K_i}{s} = \frac{10\,(10s+1)}{s}$$

K_p = 40dB (100)
K_i = 20dB (10)

DC gain = ∞ ⇒ 0% error
PM = 90°
BW = 1

(e) Yes! K_d

2. (a) $H(s) = \dfrac{1}{ms^2 - k}$ unstable

(b) $OL = \dfrac{K_p}{ms^2 - k}$

$$CL = \frac{\frac{K_p}{ms^2-k}}{1 + \frac{K_p}{ms^2-k}} = \frac{K_p}{ms^2 + (K_p - k)}$$

(c) $K_p + \dfrac{K_i}{s} = \dfrac{K_p s + K_i}{s}$

$$OL = \frac{K_p s + K_i}{s(ms^2 - k)} \qquad K_p s + K_i = K_p\left(s + \sqrt{\tfrac{k}{m}}\right)$$

$$= \frac{K_p}{ms} \cdot \frac{1}{s + \sqrt{\frac{k}{m}}}$$

$$CL = \frac{K_p}{K_p + ms^2 + \sqrt{km}\, s} \qquad \left(\zeta = 2\sqrt{\tfrac{m}{k}}\right)$$

$$\frac{1}{\zeta} = \frac{1}{2}\sqrt{\frac{k}{m}}$$

Critically damped: $K_p = \frac{1}{4}k$

$K_i = -\sqrt{\frac{k}{m}}K_p = -\frac{1}{4}k\sqrt{\frac{k}{m}}$