1.1 GM = 0db @ $W_{-180^\circ} = 0$ AND PM = 0° @ $W_{0db} = 0$ rad/sec

1.2 $e_{ss} \downarrow$ WHEN $K \uparrow$. $K^{max} = 10^{40/20} = 100$

1.3 $\lim_{t \to \infty} y(t) = \lim_{s \to 0} s \cdot r(s) \frac{1}{s+2} = \lim_{s \to 0} s \frac{1}{s} \frac{1}{s+2} = 0.5$

1.4 $G(s) = \frac{10}{s+1}$ @ w = 10 rad/sec $G(jw) \simeq 10^{0}$ $\angle -84.3^\circ$

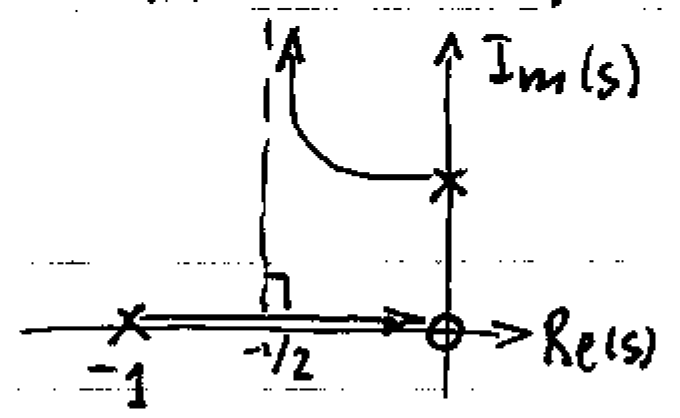
OUTPUT = $2 \cdot 10^{0} \sin(10t - 84.3^\circ)$

1.5 $s^3 + s^2 - s - 1 = (s-1)(s+1)^2 \mapsto \exists$ 1 POLE @ RHP

1.6 GM = 18.1 db @ $W_{-180^\circ} = 1.73$ rad/sec, PM = −180° @ $W_{0db} = \phi$

1.7 $10G(s) \mapsto$ GM = −1.94 db @ $W_{-180^\circ} = 1.73$, PM = −7.03° @ $W_{0db} = 1.91$

1.8



CLOSED LOOP IS STABLE FOR $K \in (0, \infty)$

2.1 $G(s) = \frac{(s+0.1)}{s^2 (s+10)^2}$

2.2 $\exists$ INFINITE SOLUTIONS. $C(s) = K$ DOES NOT SUFFICE.

A POSSIBLE CHOICE $C(s) = K \frac{s^2}{(s+0.1)(s+10)}$ RESULTS IN

$C(s) \cdot G(s) = \frac{K}{(s+10)^3}$ $\mapsto$ ANY VALUE OF $K < 200 \mapsto$ POLES OF CLOSED LOOP WITH Real Part < −5.56

3.1 $m\ddot{x} + b\dot{x} + cx^3 = F$ $x^0 = 2$ $\dot{x} = \ddot{x} = 0$ $m = b = c = 1$

$F^0 = c(x^0)^3 = 1 \cdot 2^3 = 8$

$x = x^0 + \Delta x$ $\dot{x} = \phi + \Delta\dot{x}$ $\ddot{x} = \phi + \Delta\ddot{x}$

$1 \cdot \cancel{\ddot{x}^0} + 1\Delta\ddot{x} + b\Delta\dot{x} + 1[(x^0)^3 + 3(x^0)^2 \Delta x + \ldots] = F^0 + \Delta F \Rightarrow$

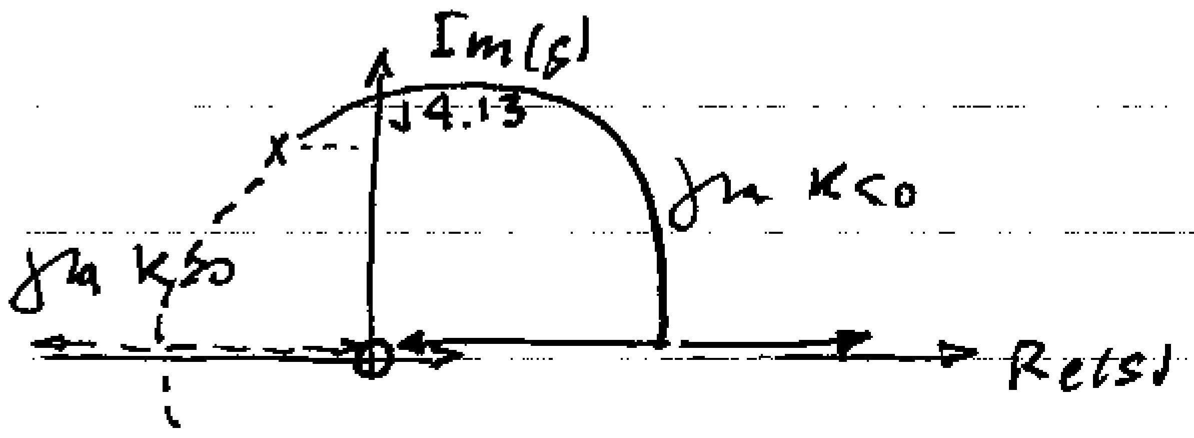
$\ddot{x} + \Delta\dot{x} + 3(2)^2 \Delta x = \Delta F \Longrightarrow \ddot{x} + \Delta\dot{x} + 12\Delta x = \Delta F$

3.2 CLOSED LOOP TR. FCN: $\frac{K}{s^2 + s + 12 + K} = \frac{K}{s^2 + 2\zeta w_n s + w_n^2}$ $\mapsto 1 = 2 \cdot 0.12 \sqrt{12+K}$

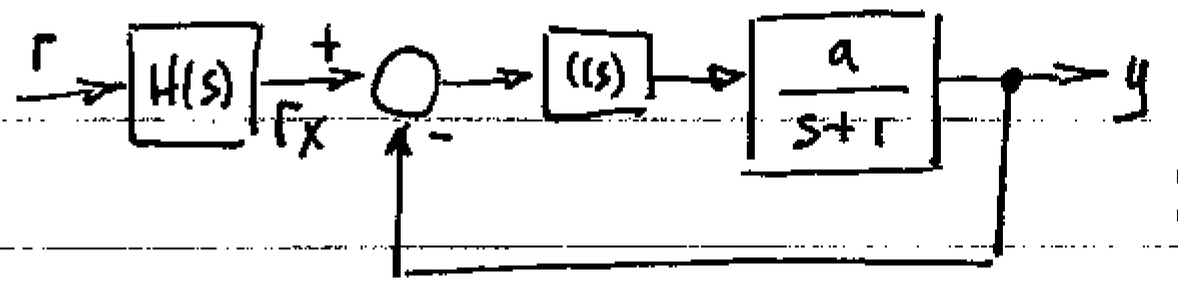
$K = 5.3611$

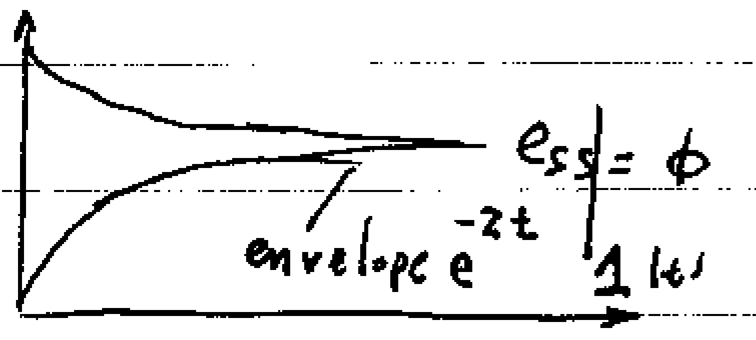
3.3 CL-POLES $s^2 + bs + 17.3611 = \phi \mapsto s^2 + s + \Delta b s + 17.3611 = \phi$ OR

$1 + \frac{\Delta b s}{s^2 + s + 17.3611} = \phi \mapsto$



4.1





Let $C(s) = K \Rightarrow \dfrac{y}{r_x} = \dfrac{Ka}{s+1+Ka}$

From the envelope $1 + Ka = 2 \Rightarrow K = 0.25$

$$\frac{y}{r_x} = \frac{1}{s+2}$$

If $H(s) = 2 \Rightarrow \dfrac{y}{r} = 2\dfrac{1}{s+2} = \dfrac{2}{s+2}$ and

$$\lim_{t\to\infty} y(t) = \lim_{s\to 0} s\,Y(s) = \lim s\,\frac{1}{s}\,\frac{2}{s+2} = 1 \quad \text{and} \quad e_{ss}\Big|_{1(t)} = \phi$$

4.2 IF a IS UNKNOWN BUT BOUNDED, THEN A CONTROLLER $C(s) = K$ DOES NOT SUFFICE

IF $C(s) = \dfrac{K}{s}(s+1)$ THEN $\dfrac{y}{r_x} = \dfrac{Ka}{s+Ka}$ IF $H(s) = 1$ $e_{ss}\Big|_{STEP} = \phi$

$Ka > 2 \quad \forall\ a \in [1, 10) \Rightarrow K > \dfrac{2}{\cancel{10}}$