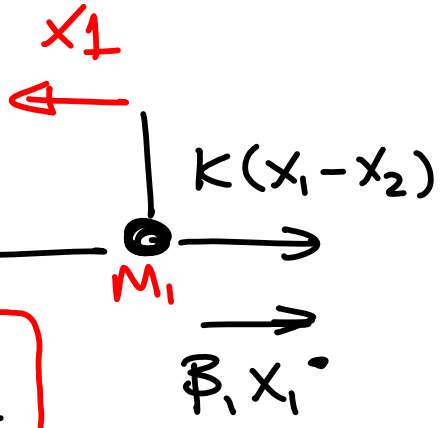
Control engineering (1)

model Ans

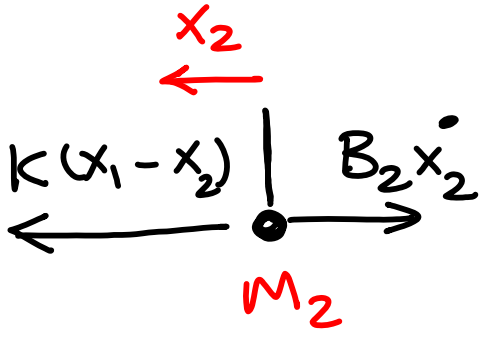
2016 – 2017

Q1 ⇒ 15 Pt



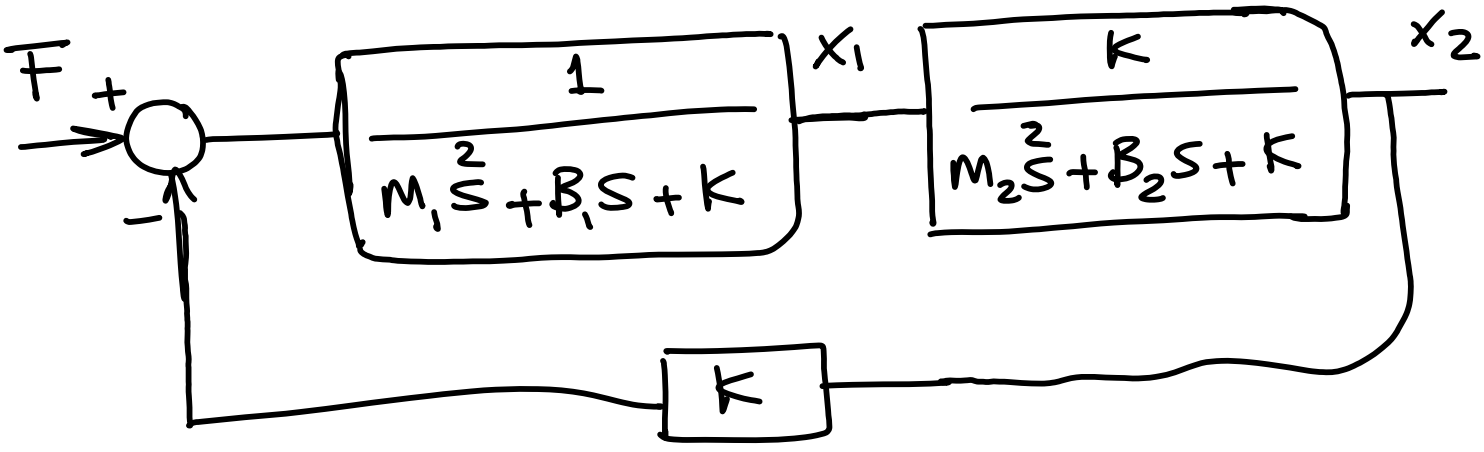
$$m_1\ddot{x}_1 = F - B_1\dot{x}_1 - K(x_1 - x_2)$$

$$(m_1 s^2 + B_1 s + K)X_1 = F + KX_2$$

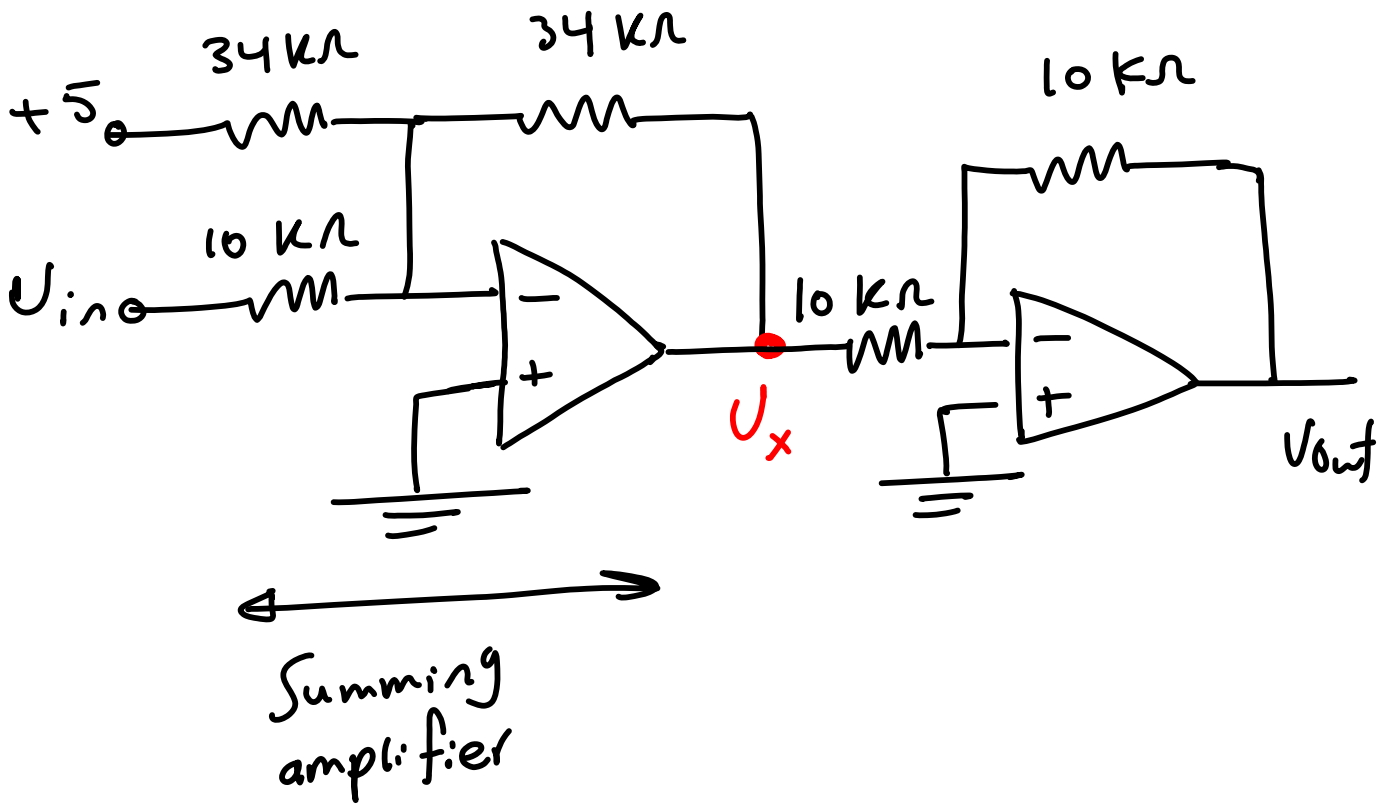


$$m_2\ddot{x}_2 = K(x_1 - x_2) - B_2\dot{x}_2$$

$$(m_2 s^2 + B_2 s + K)X_2 = KX_1$$



Q2 => 15 pt



$$V_x = -\left(\frac{34}{34}5 + \frac{34}{10}V_{in}\right)$$

$$V_x = -(5 + 3.4\,V_{in})$$

$$V_{out} = -\frac{10}{10}V_x = -V_x$$

$$\therefore \boxed{V_{out} = 3.4\,V_{in} + 5}$$

Q3 $\Rightarrow$ 15 pt

$$OS = \frac{1.25 - 1}{1} = 0.25$$

$$OS\% = 25\%$$

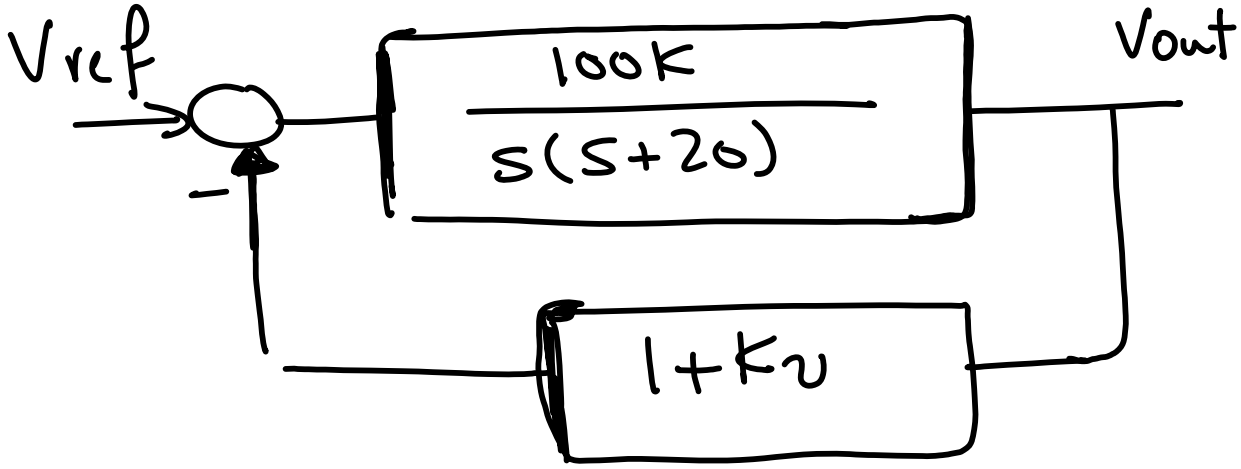
$$t_p = 0.01$$

$$\xi = \frac{-\ln(OS)}{\sqrt{\pi^2 + \ln^2(OS)}} = 0.404$$

$$\therefore t_p = \frac{\pi}{\omega_d} = \frac{\pi}{\omega_n \sqrt{1 - \xi^2}}$$

$$\omega_n = 343.4 \text{ rad/s}$$

Q4 => 15 pt



$$\frac{V_{out}}{V_{ref}} = \frac{100K}{s(s+20)+100K(1+K_v)}$$

Q5 => 15 pt

(A) $$T = \frac{s+1}{(s+1)(s^2+s+2)+1}$$

$$G_E = \frac{s+1}{s^3+2s^2+2s+2}$$

(a) $K_p = G_E(0) = 1/2$

$K_v = 0$

$K_a = 0$

(b) $SSE = \frac{1}{1+1/2} = 2/3$

(c) system must be stable

$C/CS = (S+1)(S^2+S+2)+1$

$C/CS = S^3+2S^2+3S+2$

S^3	1	3
S^2	2	3
S^1	1.5	
S^0	3	

∵ stable

(d) system type ⇒ Zero

GE Term

(B)

$C/CS = 1 + K\,GH$

$= 1 + K\frac{(S+2)}{S(S-2)}$

$= S^2 - 2S + KS + 2K$

$$C/Cs = \frac{}{s^2 + (k-2)s + 2k}$$

$$\omega_n^2 = 2k \longrightarrow (1)$$

$$2\zeta\omega_n = k-2$$

$$2 \times \frac{1}{\sqrt{2}}\omega_n = k-2$$

$$\sqrt{2}\,\omega_n = k-2$$

$$2\omega_n^2 = (k-2)^2 \longrightarrow (2)$$

$$\downarrow$$

$$2 * 2k = (k-2)^2$$

$$k^2 - 8k + 4 = 0$$

(a) $k = 7.4641$

$k = 0.5359$

(b) $k-2 = 0 \Rightarrow \underline{k=2}$

Q6 ⇒ 15 pt

$$C/CS = 1 + G(s) = 1 + \frac{K(s+a)}{s(s+1)(s+2)(s+3)} = 0$$

$$C/CS = s^4 + 6s^3 + 11s^2 + (K+6)s + Ka = 0$$

s^4	1	11	Ka
s^3	6	$(K+6)$	
s^2	$\frac{60-K}{6}$	Ka	
s^1	$\frac{b_3(K+6) - 6Ka}{(60-K)/6}$		
s^0	Ka		

$$\frac{60-K}{6} > 0$$

$$\Downarrow$$

$$K < 60$$

$$(K-60)(K+6) + 36Ka = 0$$

$$a \leq \frac{(60-K)(K+6)}{36K}$$