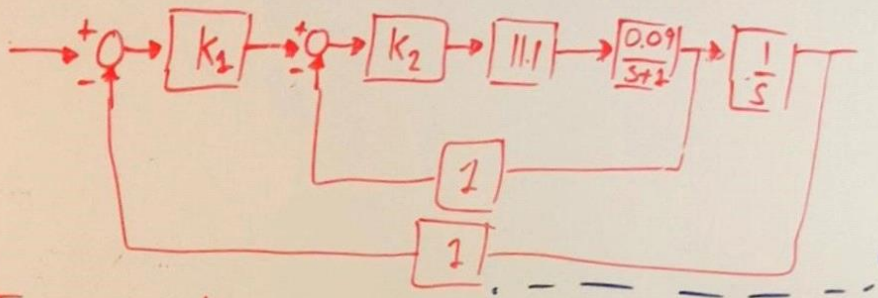
2)

a) Closed loop transfer function



$$\frac{\frac{k_2}{s+1}}{1+\frac{k_2}{s+1}} = \frac{k_2}{s+1+k_2}$$

$$T(s) = \frac{k_1 k_2}{s^2 + (k_2+1)s + k_1 k_2}$$

$M_p = 20\%$, $\zeta = 0.45$, settle time $\% = 2\%$

$t_s = 1s$

b) Find k_1 and k_2

$$t_s(x) = \frac{-\ln(x)}{\zeta \omega_n} = \frac{-\ln(0.02)}{0.45 \cdot \omega_n} = 1$$

$$\omega_n = 8.7s$$

$$2\zeta\omega_n = k_2 + 1 \Rightarrow k_2 = 2\zeta\omega_n - 1 = 6.8$$

$$\omega_n^2 = k_1 k_2 \Rightarrow k_1 = \frac{\omega_n^2}{k_2} = 11.1$$

slide 14

c) Find t_r

slide 14

$$t_r \approx \frac{1.8}{\omega_n} = \frac{1.8}{8.7} = \underline{\underline{0.21s}}$$

d) find type and SS-errors

Open loop transfer func 1 pole = 0

$$G(s) = \frac{k_1 k_2}{k_2 + s + 1} \cdot \frac{1}{s}$$, type 1

$K_p = \infty$, $K_v = \lim_{s \to 0} s \cdot \frac{k_1 k_2}{s+1+k_2} \cdot \frac{1}{s} = 6.24$

step: $e_{ss} = 0$ ← tabel

ramp: $e_{ss} = \frac{1}{K_v} = \frac{1}{6.24} = 0.16$

Parabola: $e_{ss} = \infty$ ← tabel