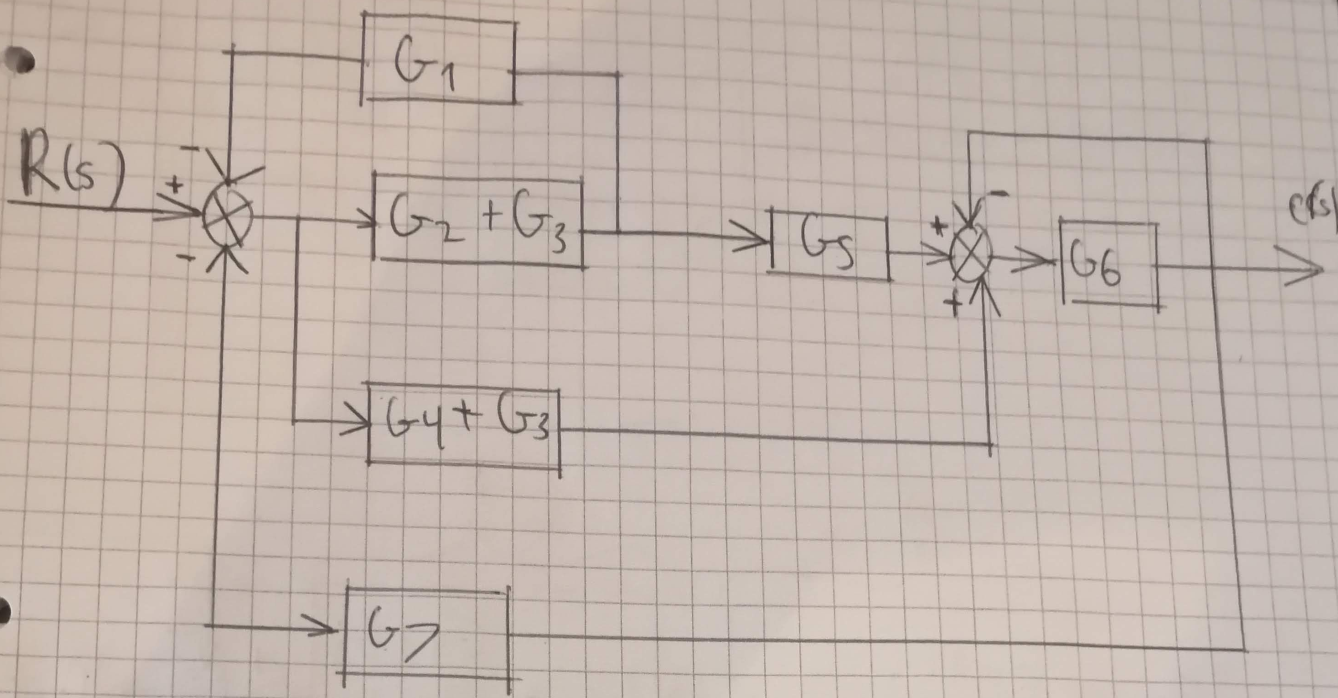
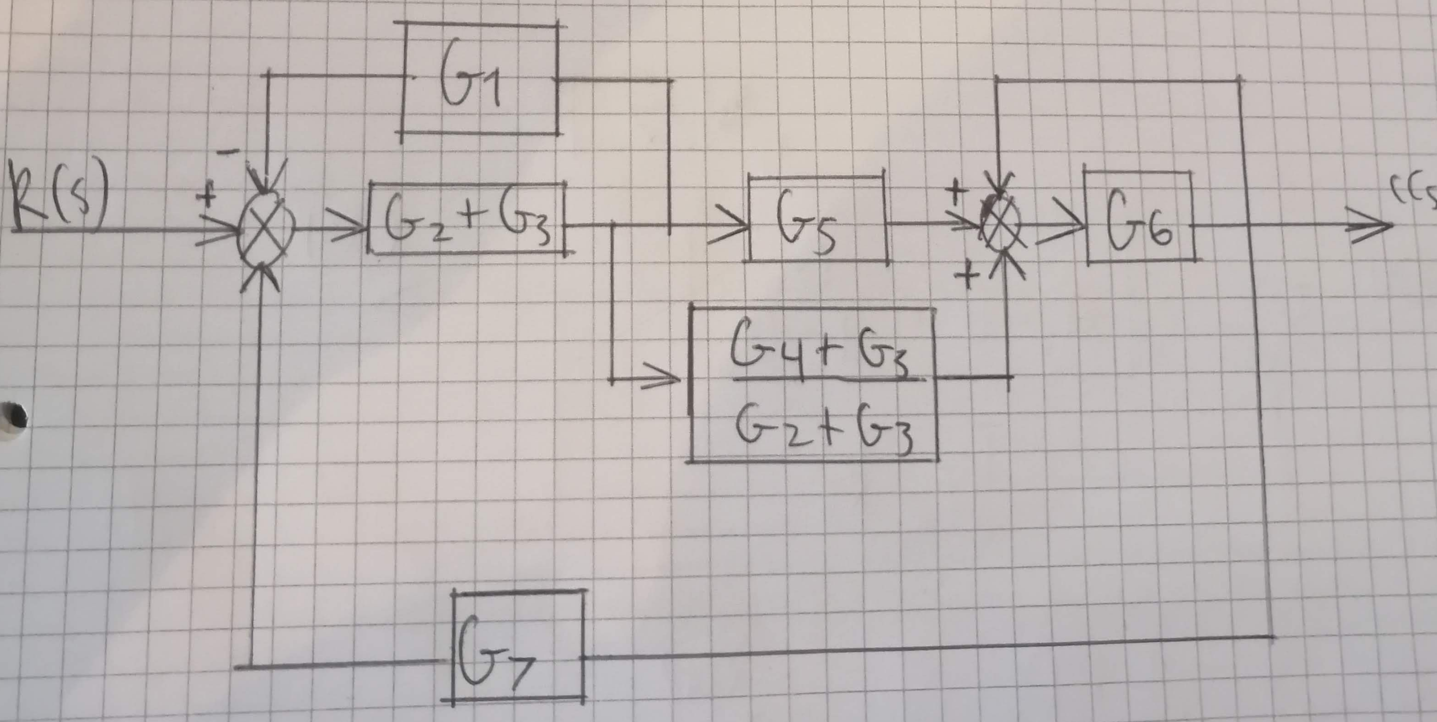
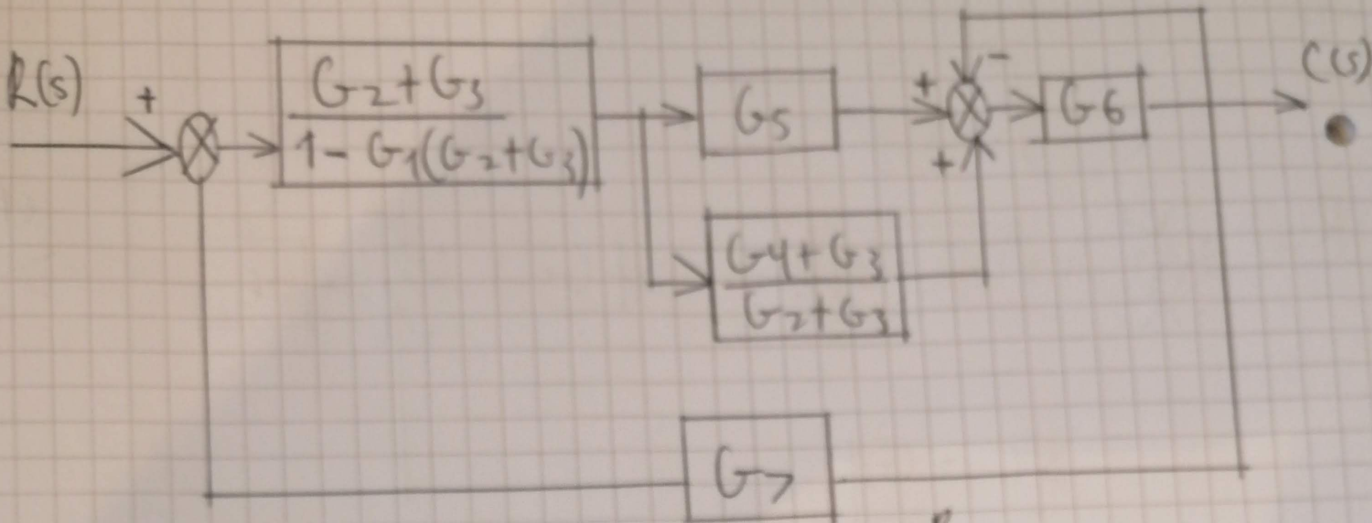
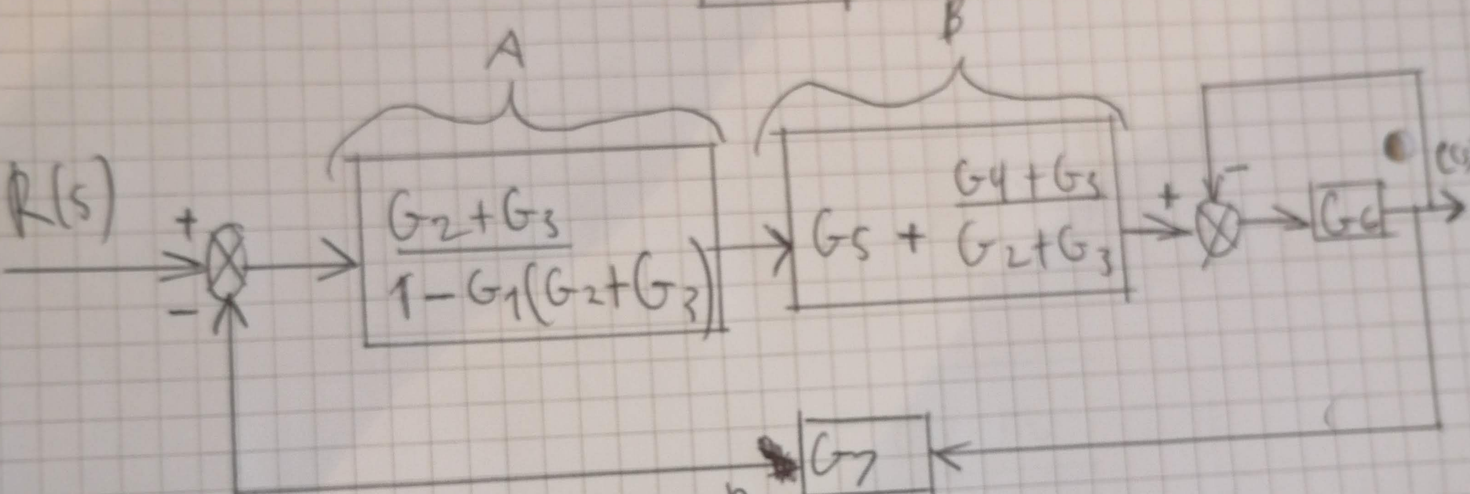
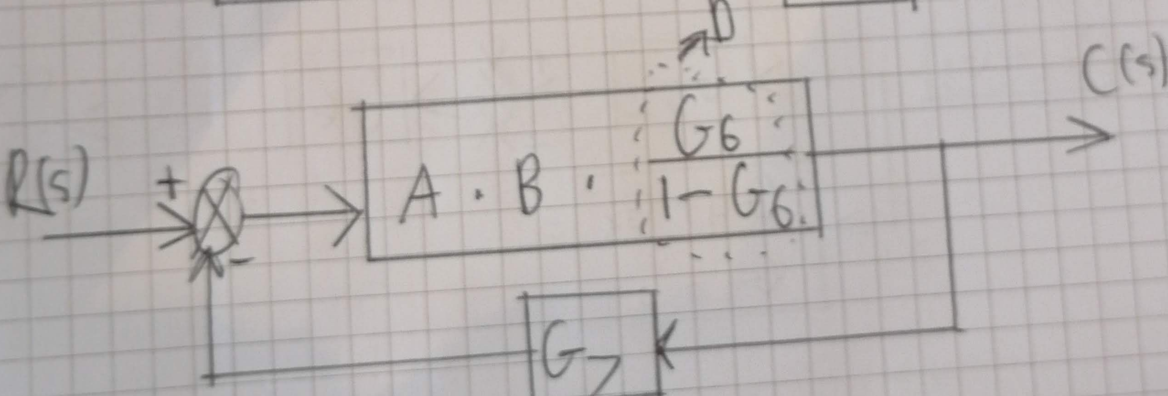
1)

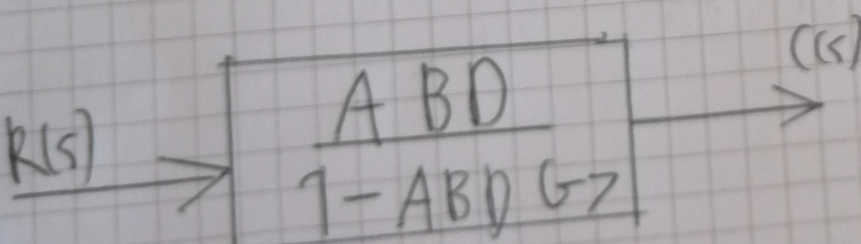




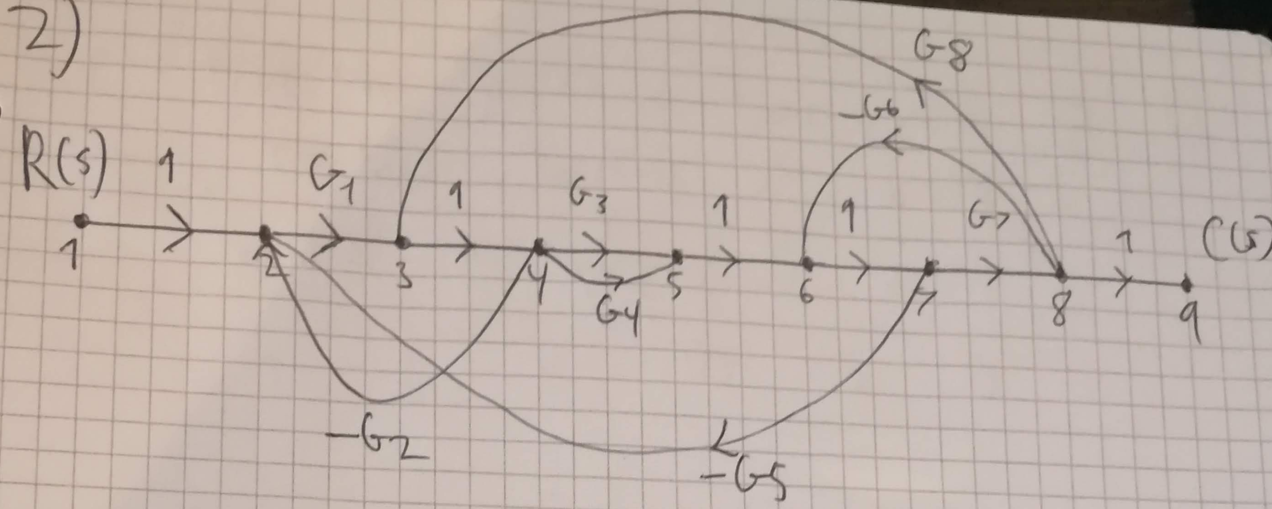

R(s)
+
$\frac{G_2+G_3}{1-G_1(G_2+G_3)}$
G_5
$\frac{G_4+G_3}{G_2+G_3}$
+
+
−
G_6
C(s)
G_7


A
B
R(s)
+
−
$\frac{G_2+G_3}{1-G_1(G_2+G_3)}$
$G_5 + \frac{G_4+G_3}{G_2+G_3}$
+
−
G_6
C(s)
G_7


D
R(s)
+
−
$A \cdot B \cdot \frac{G_6}{1-G_6}$
C(s)
G_7


R(s)
$\frac{ABD}{1-ABDG_7}$
C(s)

2)



Mason:

Paths:

$P_1 = G_1 G_3 G_7$

$P_2 = G_1 G_4 G_7$

Loop gains:

$-G_6 G_7$

$G_3 G_7 G_8$

$-G_1 G_3 G_5$

$-G_1 G_2$

$G_4 G_7 G_8$

$-G_1 G_4 G_8$

$$\cancel{\frac{C(s)}{R(s)} = \frac{P_1 + P_2}{1 - G_5 G_8 (G_3 + G_4) + G_6 G_8 (G_4 + G_3)}}$$

$$\frac{C(s)}{R(s)} = \frac{P_1 + P_2}{1 - G_7 G_8 (G_3 + G_4) + G_1 G_5 (G_4 + G_3) + G_6 G_7 + G_1 G_2}$$

3) 5: Poles must be in left-half plane to prevent system from converging on either 0 or ∞.

6: Says how many poles that is either in left-half or right-half plane, useful to determine stability of system

9: Odd or even roots in the polynomial

10: Simplifies finding the coefficients of the next row

11: Sign is indicative of where poles are, should not be changed

4) Routh diagram:

$P(s) = s^5 + 2s^4 + 5s^3 + 4s^2 + s + 2$

s^5	1	5	1
s^4	2	4	2
s^3	3	0	0
s^2	4	2	0
s^1	-3	0	0
s^0	2	0	0

3 poles in left-half plane

2 poles in right-half plane

5)

$$s(s+1)(s+3) + k(s+6) = 0$$

$$s(s^2 + 4s + 3) + ks + k6 = 0$$

$$s^3 + 4s^2 + s(3+k) + k6 = 0$$

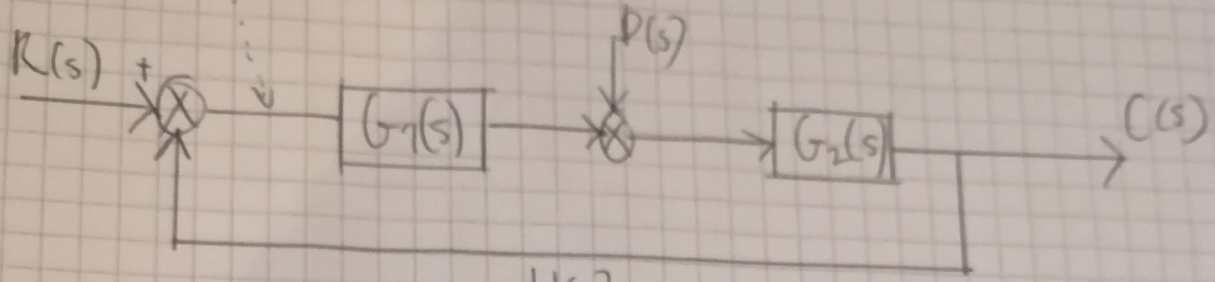
s^3	1	3k
s^2	4	6k
s^1	6-k	0
s^0	18-3k	0

$$\frac{4(3+k) - 6k}{4} = 3 - \frac{k}{2} \quad \Big| \cdot 2$$

$$\frac{(6-k)\cdot 6k - 4\cdot 0}{4k} = 6 - \frac{3k}{2} \quad \Big| \cdot 2$$

$0 < k < 6$ for stable system

6) $E(s) = R(s) - C(s)\,H(s)$



$H(s) = 1$

$$E(s) = R(s) - \left(G_1 G_2 E(s) + G_2 D(s)\right) H(s)$$

$$E(s) = \frac{R(s)}{1 + G_1 G_2} - \frac{D(s) - G_2}{1 + G_1 G_2}$$

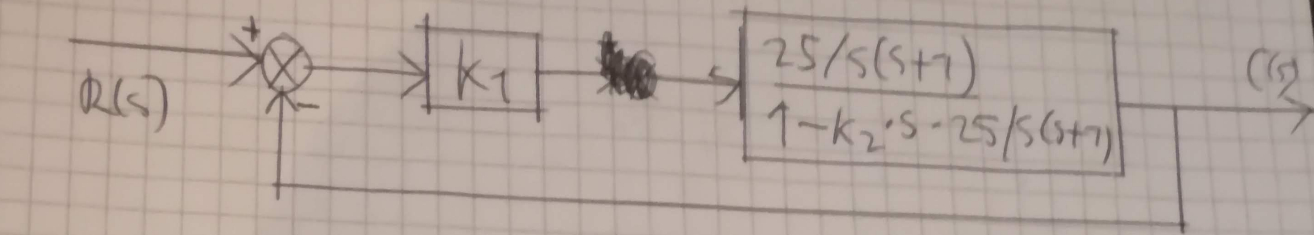
$$\lim_{s \to 0} s\,E(s) = \frac{s \cdot \frac{1}{s}}{1 + \frac{1}{s+4} - \frac{100}{s+2}} - \frac{s \cdot \frac{1}{s} \cdot \frac{100}{s+2}}{1 + \frac{1}{s+4} \cdot \frac{100}{s+2}}$$

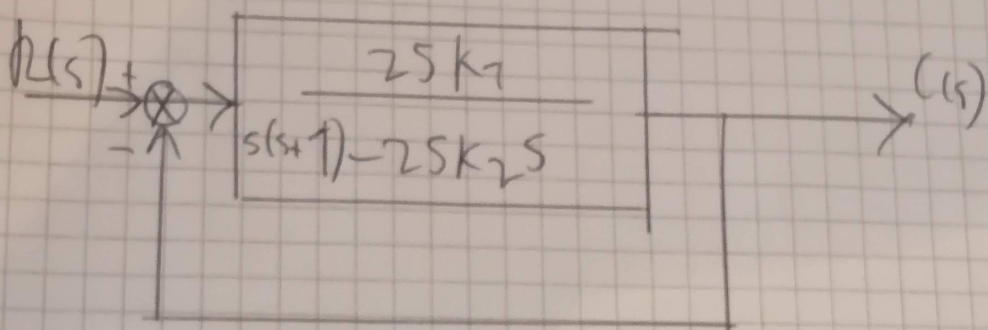
$$\lim_{s \to 0} s\,E(s) = \frac{1}{1 + \frac{100}{(s+4)(s+2)}} - \frac{100/(s+2)}{1 + \frac{100}{(s+4)(s+2)}}$$

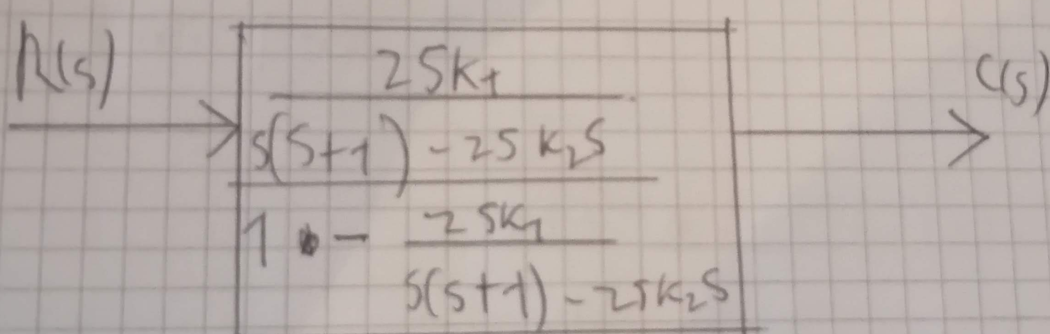
$$= \frac{1}{1 + 100/8} - \frac{50}{1 + 100/8}$$

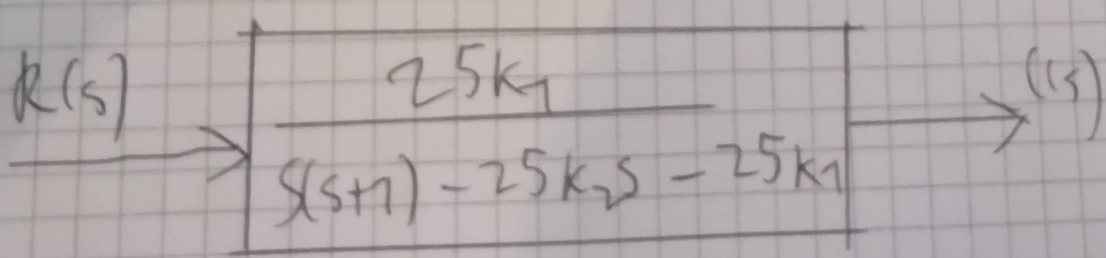
$$\approx -3{,}63$$

7) a)









$$\frac{R(s)}{C(s)} = H(s) = \underline{\underline{\frac{25k_1}{s(s+1) - 25k_2 s - 25k_1}}}$$

b) $E(s) = R(s) - C(s)$

$$E(s) = R(s) - H(s) \cdot R(s)$$

$$E(s) = R(s)\left(1 - H(s)\right)$$

$$\frac{E(s)}{R(s)} = 1 - H(s)$$

$$= \frac{s(s+1) - 25K_2 s - 25K_1}{s(s+1) - 25K_2 s - 25K_1} - \frac{25K_1}{s(s+1) - 25K_2 - 25K_1}$$

$$= \underline{\underline{\frac{s(s+1) - 25K_2 s - 50K_1}{s(s+1) - 25K_2 s - 25K_1}}}$$