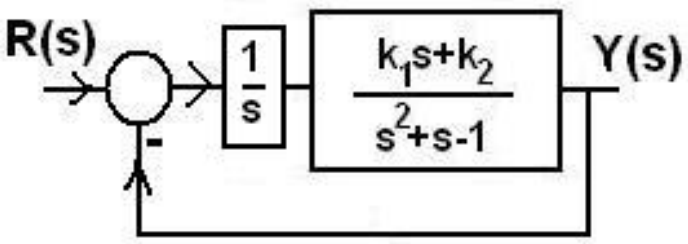
Name: ...
Id No.: ...

Eskişehir Osmangazi University - Electrical Engineering Department
Fundamentals of Control Systems – Make-up Examination - Spring 2013

For each question, put the answer just below it. Correct answers are sufficient for full credits.

1.



a [15 pts.] Find all (k_1, k_2) such that the closed loop system on the right is stable.
b [10 pts.] For a unit step input and $(k_1 = 4, k_2 = 2)$, find the steady state output $\lim_{t\to\infty} y(t)$.

Ans. a Closed loop tf: $\frac{k_1 s+k_2}{s^3+s^2-s+k_1 s+k_2}$.
Routh table:

s^3	1	$k_1 - 1$
s^2	1	k_2
s^1	$k\_1 - k_2$	
s^0	k_2	

Stable set of (k_1, k_2): $\{(k_1, k_2) : \ k_1 > 1 + k_2 \text{ and } k_2 > 0\}$

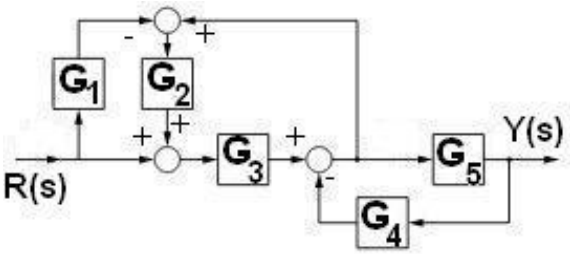
Ans. b

$$Y(s) = \frac{4s+2}{s^3+s^2+3s+2}\frac{1}{s}$$

$$\lim_{t\to\infty} y(t) = \lim_{s\to 0} sY(s) = 1$$

2. [25 pts.]

Find the transfer function $\frac{Y(s)}{R(s)}$ for the system on the right.

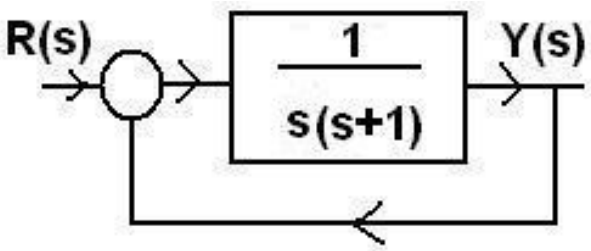


Ans.

$$f_1 : \ G_3G_5, \ f_2 : -G_1G_2G_3G_5, \ L_1 : G_2G_3, \ L_2 : -G_4G_5, \ \frac{Y(s)}{R(s)} = \frac{G_3G_5 - G_1G_2G_3G_5}{1 - G_2G_3 + G_4G_5}$$

3. [25 pts.-No partial credits]

a Find the phase margin for the system on the right.
b Is the system on the right stable?



Ans. a

$$|G(w)| = |\frac{1}{(iw)^2 + iw}| = 1 \to |\frac{1}{-w^2 + iw}| = 1 \to w^4 + w^2 - 1 = 0 \to w^2 = 0.618$$

$\to$ Gain crossover frequency: $w = 0.786$

$$\{\angle G(w)\}_{w=0.786} = \{\angle \frac{1}{iw(1+iw)}\}_{w=0.786} = -90^0 - 38^0.16 = -128^0.16$$

Phase margin: $180^0 - 128^0.16 = 51^0.84$

Ans. b Stable

4. A discrete LTI system has the transfer function $T(z) = \frac{1}{z^2+0.3z+0.02}$.
a [10 pts.] What are the poles of this system? **Ans.** $-0.1, \ -0.2$
b [10 pts.] Is this system stable? **Ans.** Yes
c [5 pts.] Find the steady state impulse response of this system. **Ans.** 0

Good Luck,
A. Karamancıoğlu