Name:
ID. No.

Eskişehir Osmangazi University - Electrical Engineering Department
Fundamentals of Control Systems- Final Examination - Spring 2026

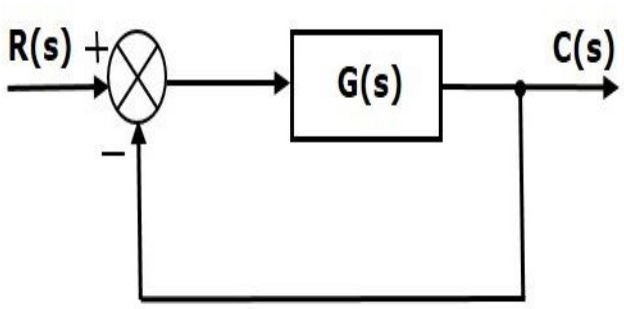
Duration: 65 minutes; **Allowed**: A calculator; **Directions**: All answers must be written below the questions. Anything written elsewhere won't be graded.

Question 1.

Consider the system below with

$$G(s) = \frac{K}{s(s+1)^2}$$

where K is a positive gain.
(a) [20 pts] Determine the phase-crossover frequency. Show all calculations.
(b) [20 pts] For K=1, determine the gain margin in dB. Show all calculations.



Solution:

$$G(iw) = \frac{K}{iw(1+iw)^2}$$

a.

$$\underline{/G(iw)} = -90^0 - 2\tan^{-1}(w) = -180 \rightarrow \tan^{-1}(w) = 45 \rightarrow w_{pc} = 1$$

b. *Magnitute at* $w = 1$ *is*

$$|G(i\cdot 1)| = |\frac{K}{i\cdot 1\cdot(1+i\cdot 1)^2}| = \frac{K}{2}$$

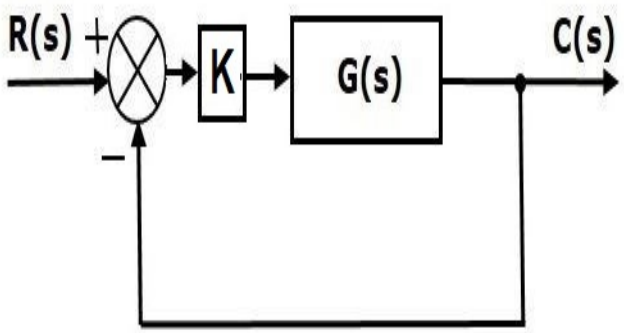
$$Gain\ margin = \frac{1}{|G(i1)|} = \frac{1}{\frac{K}{2}} = \frac{2}{K}$$

In dB: $20\log(\frac{2}{K})$. *If* $K = 1$ *then it is:* $20\log 2 = 6.02\ dB$

Question 2.

Consider the system below with

$$G(s) = \frac{(s+5)}{((s-1)^2+1)((s+2)^2+4)}$$

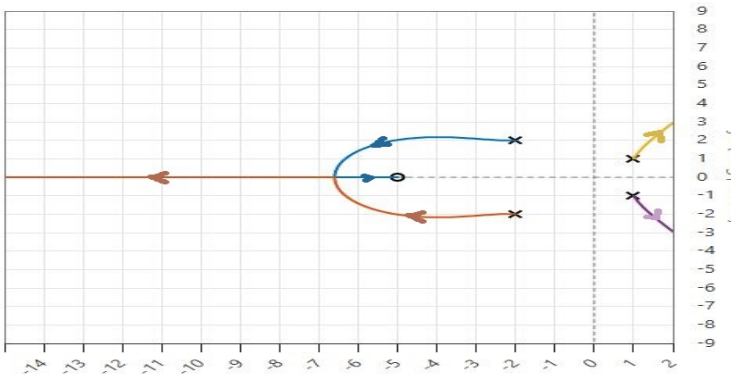


(a) [20 pts] Sketch the root locus and indicate the direction of increasing K with arrows. (You do not need to calculate any axis crossing points, breakaway points, or departure/arrival angles.)

(b) [20 pts] Using the root locus obtained in part (a), determine the values of K for which the closed-loop system is stable. Show your work.

Solution

a.



b. Root locus shows that two of the closed loop system poles are in the right half plane for every positive K value. Thus, the closed-loop system is unstable for every positive K value.

Question 3.

[20 pts.] Given the transfer function

$$G(s) = \frac{1000}{(s+5)(s+3)(s+1)}$$

determine the steady-state response of the system to the input signal $u(t) = \cos(12t)$. *Show all calculations. A maximum error of 5% in the final answer is acceptable.*

Solution

$$|G(iw)| = \frac{1000}{13 \cdot 12.369 \cdot 12.042} = 0.5164$$

$$\underline{/G(iw)} = 0 - \left[\tan^{-1}\frac{12}{5} + \tan^{-1}\frac{12}{3} + \tan^{-1}\frac{12}{1}\right] = -228.58^0 \ \ or \ \ -3.99rad$$

The steady state response is therefore

$$0.5164\cos(12t - 3.99)$$
