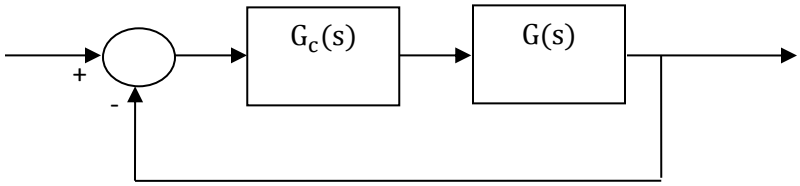
Consider the following system for questions (8-17)



where,

$$G(s) = \frac{A(1-\frac{s}{\omega_1})}{1+\frac{s}{Q\omega_2}+\left(\frac{s}{\omega_2}\right)^2}$$

$A = 12{,}000$

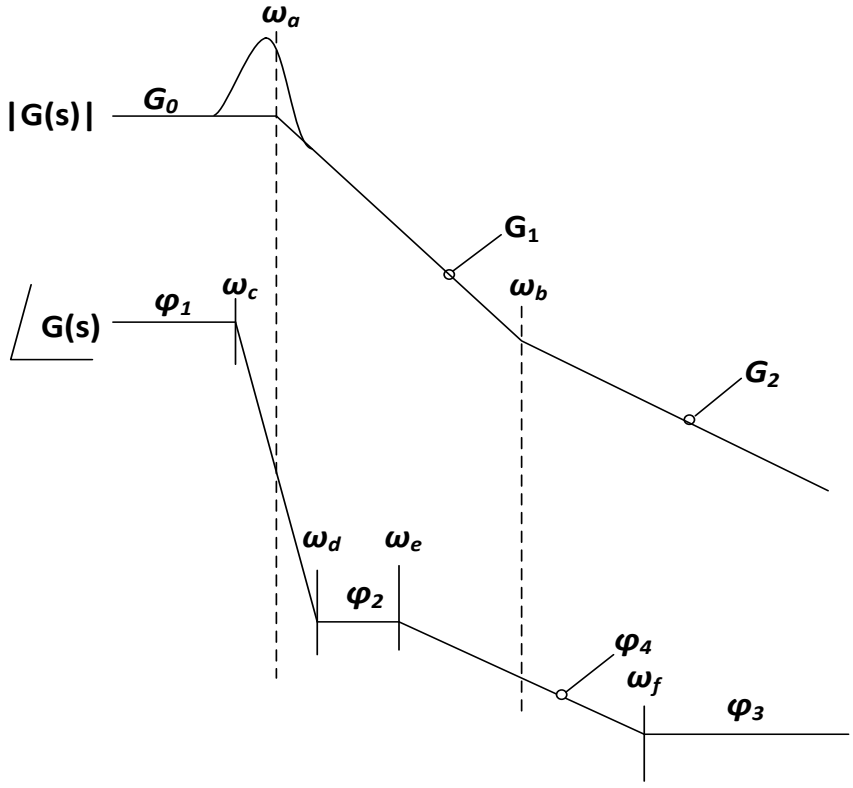
$\omega_1 = 300 rds/s$

$\omega_2 = 10 rds/s$

$Q = 1.6$

[Hint: $10^{1/2Q} \approx 2$]

Except where noted, we will assume $G_c(s)$ =1. The asymptotic Bode plot of $G(s)$ is shown below.



8. The expression for the gain G_1 along the sloping line segment is
    a. $\frac{A\omega_2}{\omega}$
    b. $A\left(\frac{\omega}{\omega_2}\right)^2$
    c. $A\left(\frac{\omega_2}{\omega}\right)^2$
    d. $A\omega$
    e. $\left(A\frac{\omega}{\omega_2}\right)^2$

9. The expression for the gain G_2 along the sloping line segment is
    a. $\frac{A{\omega_2}^2}{\omega_1\omega}$
    b. $A\left(\frac{\omega_2}{\omega\omega_1}\right)^2$
    c. $\frac{A\omega_1{\omega_2}^2}{\omega}$
    d. $A\omega$
    e. $\left(A\frac{\omega\omega_1}{\omega_2}\right)^2$

10. The frequency ω_c shown in the above plot has an approximate value of
    a. 5 rds/s
    b. 20 rds/s
    c. 1 rds/s
    d. 30 rds/s
    e. None of the above

11. The expression for the phase ϕ_4 along the sloping line segment is
    a. $-180 - 45\log_{10}(\frac{10\omega}{\omega_1})$
    b. $-270 + 45\log_{10}(\frac{10\omega_1}{\omega})$
    c. $-180 - \arctan(\frac{\omega}{\omega_1})$
    d. Both (a) and (c)
    e. (a), (b) and (c)

12. Unity gain crossover frequency is
    a. 2000rds/s
    b. 3500rds/s
    c. 4000rds/s
    d. 5000rds/s
    e. None of the above

13. The phase margin is
    a. 90
    b. 0
    c. -180
    d. -90
    e. -270

14. The steady state error of the closed loop system for a unit step (assuming $G_c(s) = 1$) is
    a. 0
    b. 1
    c. 0.5
    d. ∞
    e. 2

15. We now use a compensator such that $G_c(s) = \frac{K}{s}$ where K is a constant. The value of K required so that the loop gain has a unity gain crossover frequency of 2 rds/s is
    a. 10×10^{-3}
    b. 2×10^{-3}
    c. 10
    d. $\frac{1}{12} \times 10^{-3}$
    e. $\frac{1}{6} \times 10^{-3}$

16. For your design of question (15), the phase margin is
    a. 90
    b. 0
    c. -180
    d. -90
    e. -270

17. For your design of question (15), the steady state error of the closed loop system to a unit step is
    a. 1
    b. 0.5
    c. ∞
    d. 2
    e. 0