Indian Institute of Technology Bombay — Aerospace Engineering
AE 308 **Control Theory** — Assignment 2
AE 775 **System Modelling, Dynamics and Control** — November 5, 2022

1. **[10]** Consider a system whose closed-loop transfer function is $\frac{C(s)}{R(s)} = \frac{K(T_2 s+1)}{T_1 s+1}$
   Obtain the steady-state output of the system when it is subjected to the input $r(t) = Rsin\omega t$

2. **[5+5]** Sketch the polar plots of the open-loop transfer function
   $G(s)H(s) = \frac{K(T_a s+1)(T_b s+1)}{s^2(Ts+1)}$
   when

   (a) $T_a > T > 0, T_b > T > 0$

   (b) $T > T_a > 0, T > T_b > 0$

3. **[5+5]** A Nyquist plot of a unity-feedback system with feedforward transfer function $G(s)$ is shown in the Figure 1.

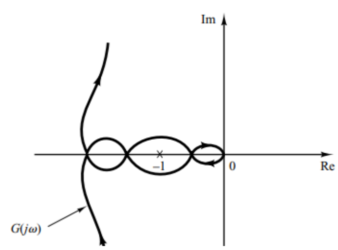

Figure 1:

   (a) If $G(s)$ has one pole in the right-half s plane, is the system stable?

   (b) If G(s) has no pole in the right-half s plane, but has one zero in the right-half s plane, is the system stable?

4. **[10]** Consider the system shown in Figure 2. Draw a Bode diagram of the open-loop transfer function, and determine the value of the gain K such that the phase margin is 50^o. What is the gain margin of this system with this gain K?

5. **[10]** A bode diagram of the open-loop transfer function $G(s)$ of a unity-feedback control system is shown in Figure 3. It is known that the open-loop transfer function is minimum phase. From the diagram, it can be seen that there is a pair of complex-conjugate poles

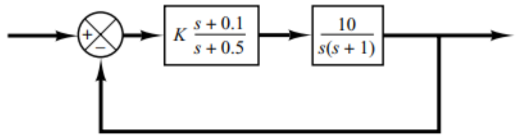

Figure 2:

at $\omega = 2rad/s$. Determine the damping ratio of the quadratic term involving these complex-conjugate poles. Also, determine the transfer function $G(s)$.

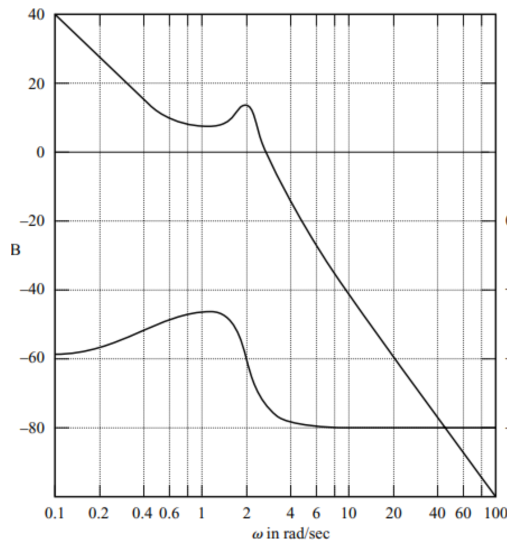

Figure 3:

6. **[10]** The Figure 4 show a block diagram of a space-vehicle attitude-control system. Determine the proportional gain constant k_p and the derivative time T_d such that the band-width of the closed-loop system is 0.4 to 0.5 rad/sec. (Note that the closed-loop bandwidth is close to the gain crossover frequency.) The system must have an adequate phase margin. Plot both the open-loop and closed-loop frequency response curves on Bode diagrams.

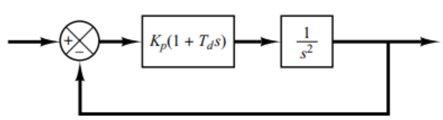

Figure 4:

7. **[10]** Consider the unity-feedback system with the following $G(s) = \frac{1}{s(s-1)}$
Suppose that we choose the Nyquist path as shown in Figure 5. Draw the corresponding

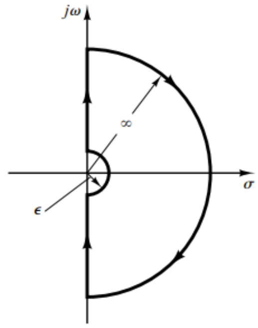

Figure 5:

$G(jw)$ locus in the G(s) plane. Using the Nyquist stability criterion, determine the stability of the system.

8. **[15]** Consider the system shown in Figure 6. Plot the root loci as the value of k varies from 0 to ∞. What value of k will give a damping ratio of the dominant closed-loop poles equal to 0.5? Find the static velocity error constant of the system with this value of k.

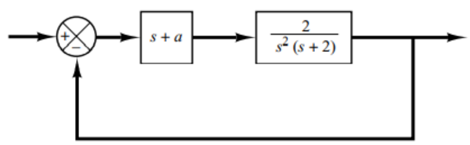

Figure 6:

9. **[15]** Referring to the system in Figure 7, design a compensator such that the static velocity error constant K_v is $20sec^{-1}$ without appreciably changing the original locaiton $(s = -2 \pm j2\sqrt{3})$ of a pair of the complex-conjugate closed-loop poles.

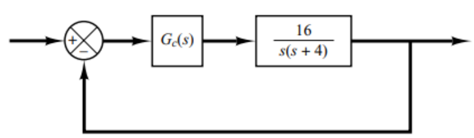

Figure 7: