1. (25%) Please answer the following questions briefly.

   1.a (5%) Given two second-order systems, how do we determine which one has a better transient performance?

   1.b (5%) Is it true that the step response of a second-order system must be oscillatory? If yes, state the reasons. If no, what is the condition that it will not be oscillatory?

   1.c (5%) Consider a system given by $G(s)=\frac{1}{s^2+1}$. The stability of this system is said to be "marginally stable". It means that most bounded inputs will result in bounded outputs, but there exist some particular bounded inputs that will result in unbounded outputs. Please give an example of bounded input signal that will result in unbounded output response.

   1.d (5%) In considering the accuracy of a control system, we usually focus on the "steady state" only. Why is that？

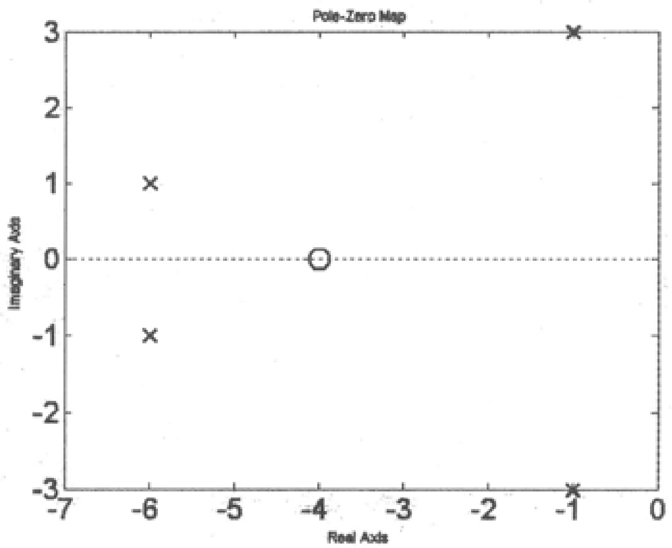
   1.e (5%) Why do we use test signals (such as step input and ramp input) in evaluating the steady state error of a system？

2. (25%) Suppose that the poles (denote by x) and zeros (denote by o) of a system are plotted on the complex plane as shown in the figure below.

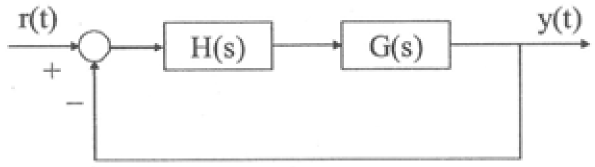
   2.a (5%) Please identify its dominant poles.

   2.b (10%) Estimate its settling time Ts and percent overshoot OS% by neglecting non-dominant poles and zeros.

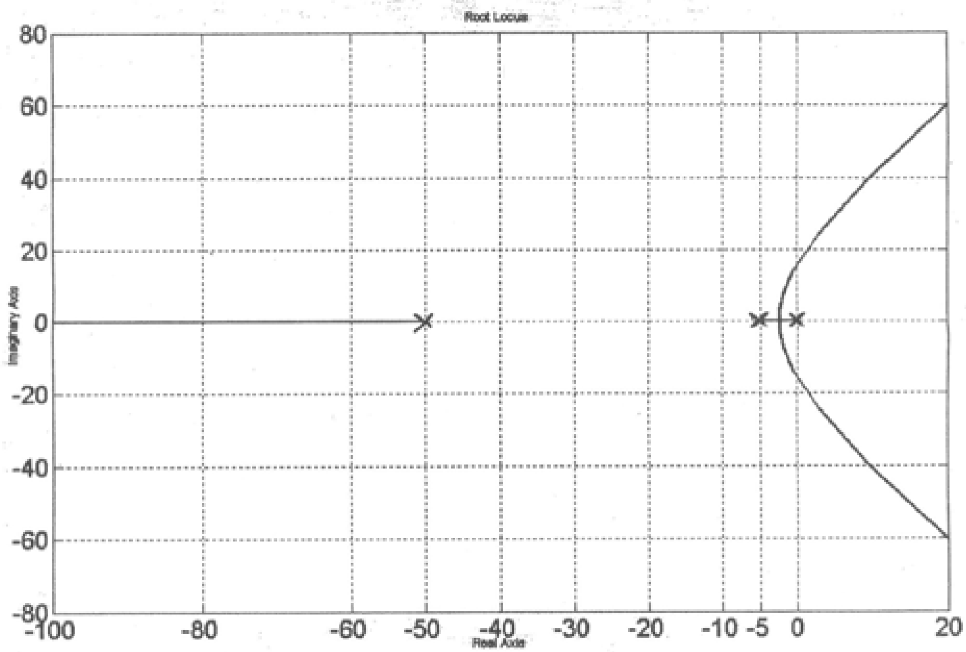
   2.c (10%) Comment on the difference between actual Ts, OS% and your estimation.



3. (30%) Consider the following feedback system



3.a (5%) With H(s) = K, K > 0 being a proportional control, identify the poles and zeros of the plant dynamics G(s) from the following root locus.



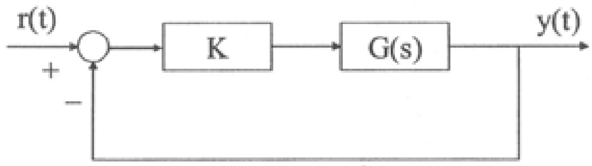
3.b (5%) For the plant identified in part (a), discuss why it is impossible to design a proportional feedback such that its unit-step response satisfies $t_{s,2\%} \le 0.4$ sec, $\%OS \le 5\%$, and $t_p \le \pi/5$ sec.

3.c (10%) In order to satisfy the transient requirements specified in part (b), a PD control is designed such that the new root locus passes two complex poles -15 ± j10. Determine the PD control. (You may need the following approximate values: $\angle(-15+j10) \approx 2.55$, $\angle(-10+j10) \approx 2.36$, $\angle(35+j10) \approx 0.28$, and $\pi \approx 3.14$, $\tan(2.05) \approx -1.92$)

3.d (5%) With the PD control determined in part (c), estimate the third closed-loop pole.

3.e (5%) With the PD control determined in part (c), discuss the behavior of the unit-step response of the closed-loop system in terms of $t_{s,2\%}$, %OS, and t_p.

4. (20%) Consider the closed-loop system as shown below



where $G(s)=\dfrac{1000}{s(s+10)(s+100)}$ and $K>0$.

4.a (10%) Draw the approximate Bode magnitude and phase plots of G(s).

4.b (10%) Use the Bode plots to determine the gain margin and phase margin of the closed-loop system.