1. (15%) Using Mason's rule, please find the transfer function, $T(s) = C(s)/R(s)$, for the system represented as shown in Fig. P1 .

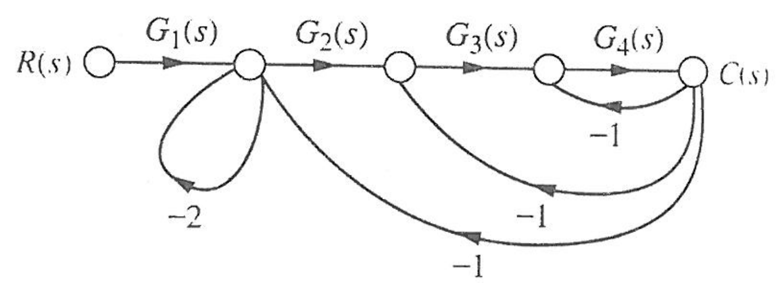

Fig. P1

2. (15%) Given the system as shown in Fig. P2, please find the sensitivity of the steady-state error to parameter a. Assume a step input.

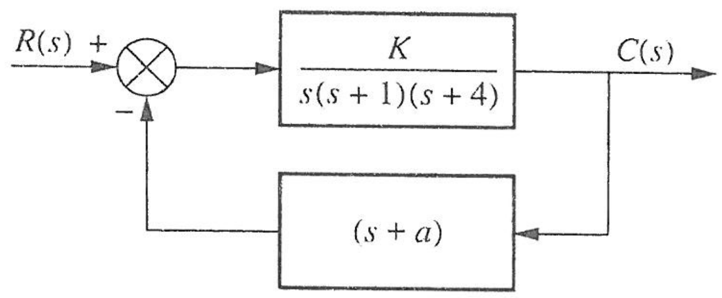

Fig. P2

3. (20%) For the unity feedback system as shown in Fig. P3, where $G(s) = \dfrac{K(s-1)(s-2)}{s(s+1)}$.

Please do the following:

3.a (5%) Sketch the root locus.
3.b (5%) Find the breakaway and break-in points.
3.c (5%) Find $j\omega$–axis crossing points.
3.d (5%) Find the range of gain to keep the system stable.

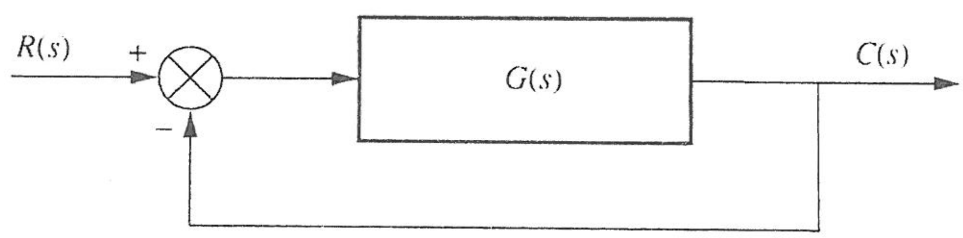

Fig. P3

4. (15%) Consider an undamped 2^{nd} order system and its unit-step response as shown in Fig. P4.

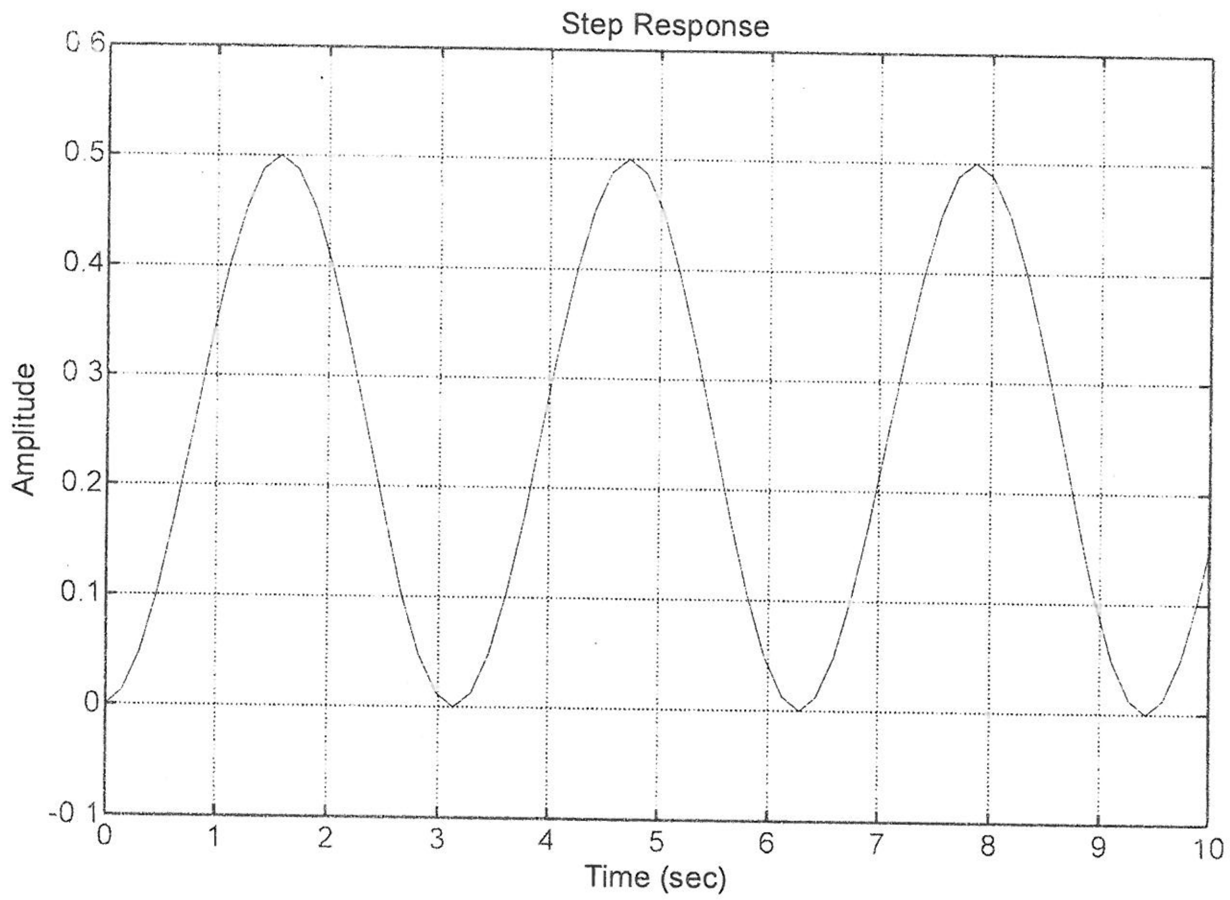

Fig. P4

4.a (5%) Use the unit-step responses to determine the transfer function of the undamped system.

4.b (10%) Let G(s) denote the transfer function of the undamped system. Determine the PD (proportional-derivative) feedback control as shown in Fig. P4b such that the closed-loop system becomes an underdamped system with peak time = 1 sec and percent overshoot = 5%.

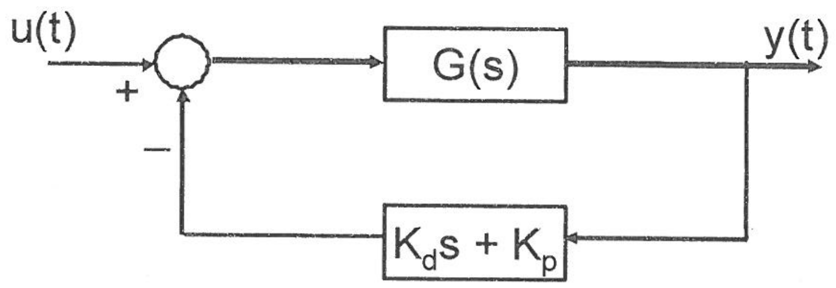

Fig. P4b

5. (15%) Consider the transfer function $G(s)=\frac{10}{(s+10)(s+1)^2}$

5.a (5%) Find its impulse response.
5.b (5%) Find its unit-step response.
5.c (5%) Use final value theorem to calculate the steady-state value of the unit-step response.

6. (20%) Consider the transfer functions $G_1(s)=\frac{10}{(s+10)(s+1)^2}$ and $G_2(s)=\frac{2(s+5)}{(s+10)(s+1)^2}$

6.a (10%) Use the unit-step response of $G_1(s)$ to explain the concept of dominant pole.
6.b (5%) Find an approximate transfer function of $G_1(s)$ including only the dominant pole such that it has same steady-state value in the unit-step response as $G_1(s)$ does.
6.c (5%) Use $G_2(s)$ to discuss the effect of additional LHP zero on the unit-step response.