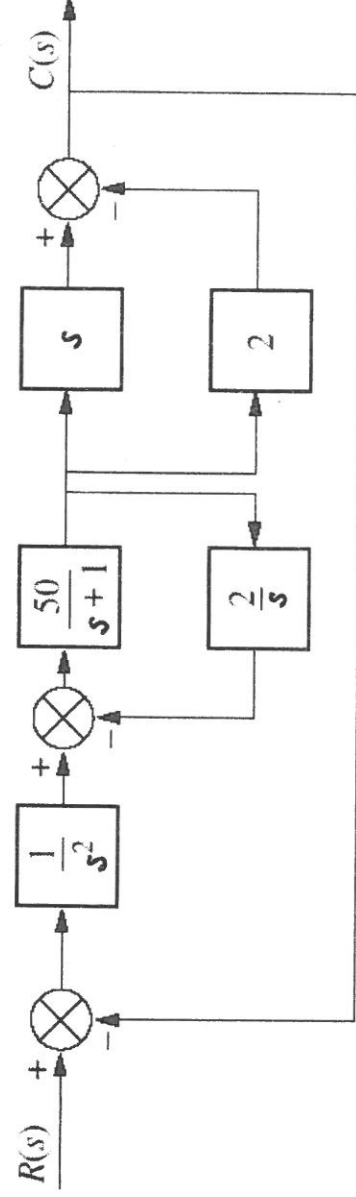
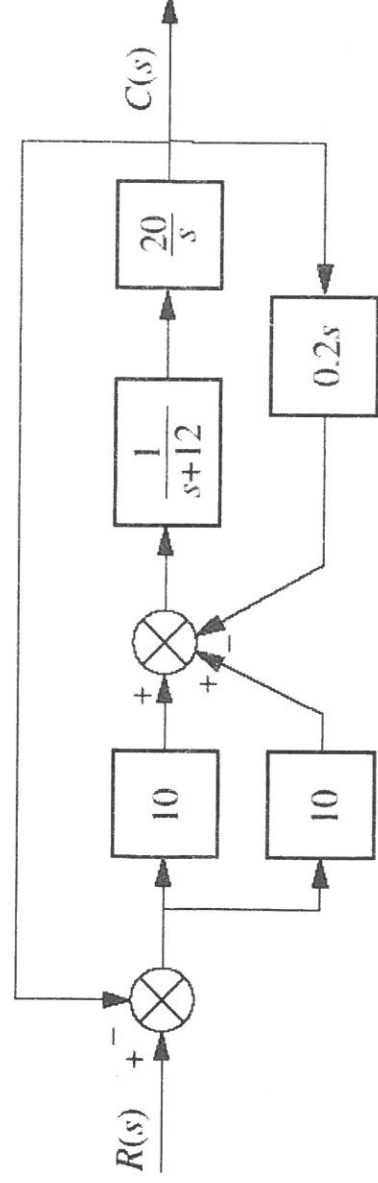


1. Reduce the block diagram shown below to a single transfer function using block diagram reduction.

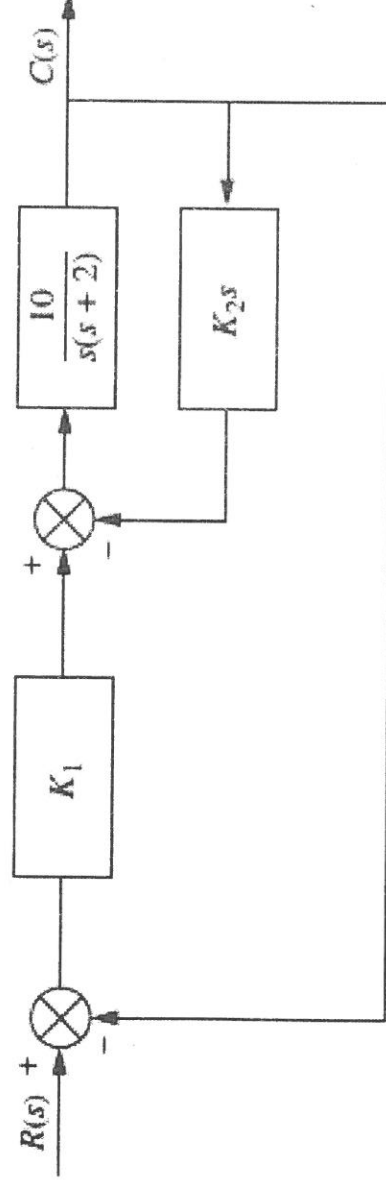
(a) (10%)



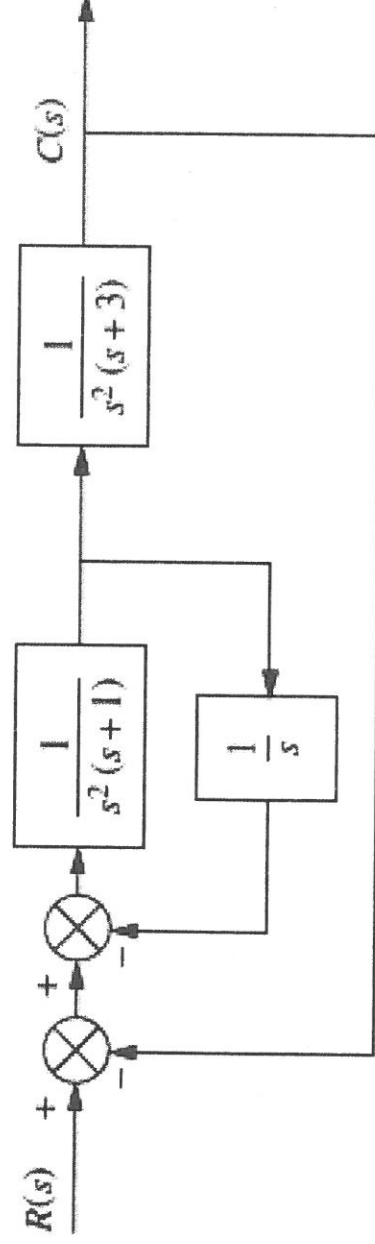
(b) (10%)



2. (10%) For the system shown below, find the values of K_1 and K_2 to yield a peak time of 1 second and a settling time of 2 seconds for the closed-loop system's step response.



3. Given the system in below, find the following:



- (5%) The closed-loop transfer function.
- (5%) The system type.
- (5%) The steady-state error for an input of $5u(t)$.
- (5%) The steady-state error for an input of $5tu(t)$.

4. A negative unity feedback system has the forward transfer function

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

- (10%) Please find the **root sensitivity** of the system (Note: the root sensitivity is defined as the ratio of the fractional change in a closed-loop pole to the fractional change in a system gain, K).
- (10%) If K is set to 20, find the **changes in closed-loop pole location** for a 10% change in K .

5. Consider the system in Fig. 5(a):

(10%) (a) What is the **steady-state error for a ramp input** if the input is introduced to the system through a proportional-plus-derivative filter, as shown in Fig. 5(b). Note: the error $e(t)$ is given by $r(t) - c(t)$.

(10%) (b) Is it possible to eliminate the steady-state error by properly setting the value of k ? If yes, what is the value of k ?

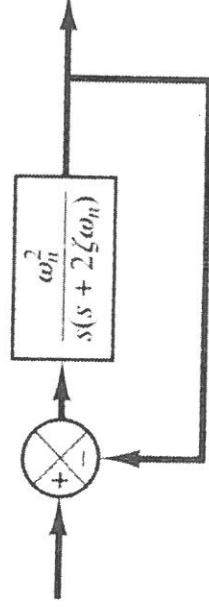


Fig. 5(a)

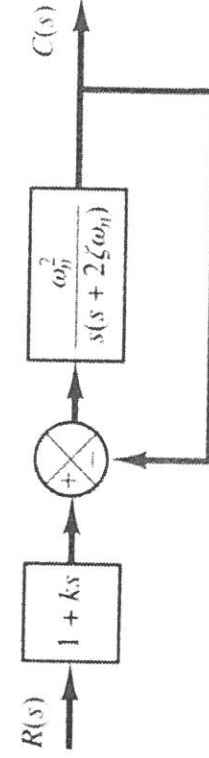


Fig. 5(b)

6. (5%) (a) How is the gain adjustment related to the transient response on the Bode diagrams?
 (5%) (b) From the Bode diagram point of view, explain how a lead network increases the speed of the transient response.