3. (35%) Consider the following feedback control system

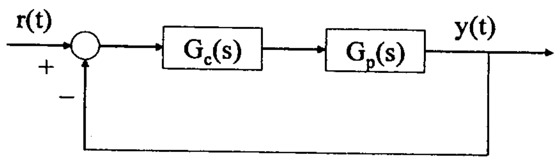

Figure 3

where $G_p(s)=\dfrac{1}{s(s+1)}$ and $G_c(s)$ a feedback controller. Design $G_c(s)$ such that the closed-loop step response satisfies the following requirements, (i) rise time ≤ 0.6 sec, (ii) percentage overshoot ≤ 5%, and (iii) settling time ≤ 2 sec.

(a) (6%) Translate the above performance requirements into requirements on the locations of the closed-loop poles.

(b) (4%) Assume $G_c(s)$ is a proportional control. Use the root-locus method to determine if there is a suitable proportional gain for which the above performance requirements are satisfied.

(c) (10%) Assume $G_c(s)$ is a proportional-derivative (PD) control. Use the root-locus method to find an appropriate PD control such that the performance requirements are satisfied. Note that you are not required to calculate exact proportional and derivative gains. All you need is to describe your procedure and discuss the feasibility of your approach.

(d) (5%) Assume $G_c(s)$ is a compensator with $G_c(s)=k_c\dfrac{s+a}{s+b}$. What is the physical meaning for $G_c(s)$ to be a lead compensator?

(e) (10%) Assume $G_c(s)$ is a compensator. In order to meet the performance requirements, will you choose a lead compensator or a lag one? Discuss your answer from the viewpoint of root-locus reshaping.