1. (25')The open-loop transfer function of the unity-feedback system is given by:

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

Design a series of lead-lag compensators to ensure the system meets the following specifications:

(a) The phase margin $\gamma \geq 45^{\circ}$

(b) Steady-state error under a unit ramp input $e_{ss} < \frac{1}{15}$

(c) The cutoff frequency $\omega_c \geq 7.5 rad/s$

2. (35')The open-loop transfer function of the unity-feedback system is given by:

$$G(s) = \frac{K}{s(0.1s+1)(0.01s+1)}$$

Design a series compensator to ensure the system characteristics meet the following specifications (hint: Use a lag-lead compensator.):

(1) The static velocity error constant $K_v \geq 250 s^{-1}$

(2) The cutoff frequency $\omega_c \geq 30 rad/s$

(3) The phase margin $\gamma(\omega_c) \geq 45^{\circ}$

3. (20+20=40')The open-loop transfer function of the unity-feedback system is given by:

$$G(s) = \frac{K}{s(s+1)(0.25s+1)}$$

(a) Given the requirements that the static velocity error constant $K_v \geq 5(s^{-1})$ and phase margin $\gamma \geq 45^{\circ}$, design a series compensator for the system.

(b) In addition to the above performance requirements, if the compensated system is required to have a cutoff frequency $\omega_c \geq 2 rad/s$, design a series compensator for the system.(hint: Initially, use a lead compensator $G_c(s) = \frac{s+1}{0.08s+1}$)