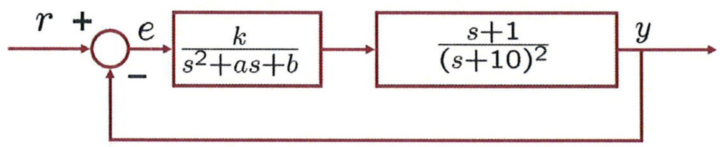
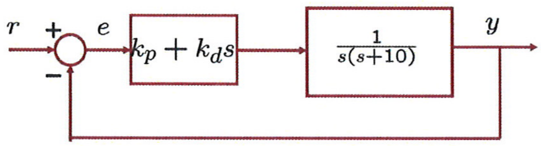
Q 1[15pts]



Consider the feedback system shown in the figure with transfer function $G(s) = \frac{s+1}{(s+10)^2}$ and a controller of the form $C(s) = \frac{k}{s^2+as+b}$, where $k > 0$.

1. (10pts) Determine values of a, b and a range of values for k, so that the feedback system can track a ramp input $r(t) = t,\ t > 0$ with zero steady state error.

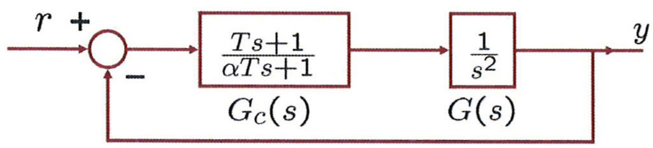
2. (5pts)A block diagram of a servo system for motion control is shown in the Figure below:



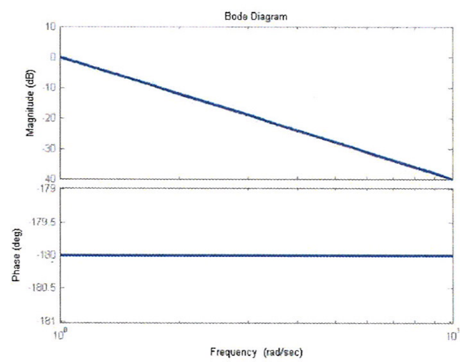
The plant transfer function is given by $G(s) = \frac{1}{s(s+10)}$. For the unity feedback setup, design a Proportional-Derivative controller such that the resulting closed loop system has a damping $\zeta = \frac{1}{\sqrt{2}} = 0.707$ and a natural frequency $\omega_n = 8\ rad/s$. (Note that a second order system of the form $\frac{A}{s^2+2\zeta\omega_n s+\omega_n^2}$ has a damping ζ and natural frequency ω_n.)

Q. 2 (15pts)

Consider the figure given below. Design a lead controller $G_c(s) = \frac{Ts+1}{\alpha Ts+1}$ for the plant $G(s) = \frac{1}{s^2}$ such that



the phase margin is 45^o. The bode plot of $G(s)$ is given below. *Hint: The frequency* ω_m *at which the phase of* $G_c(j\omega)$ *is a maximum is* $\omega_m = \frac{1}{T\sqrt{\alpha}}$..



Q. 3 (10pts)

Consider the systems with the following transfer functions:

$$G_A(s) = \frac{1}{s^2+0.5s+1}$$

$$G_B(s) = \frac{4}{s^2+1s+4}$$

$$G_C(s) = \frac{3}{2s^2+2s+2}$$

$$G_D(s) = \frac{6}{s^2+2s+4}$$

$$G_E(s) = \frac{4}{s^2+2s+4}$$

$$G_F(s) = \frac{12}{2s^2+2s+8}$$

You are required to match these with the unit step responses shown below (*Hint: calculate the damping ζ, the natural frequency ω_n for each system and the corresponding steady state output values*).