1. What is the dominant pole of an automatic control system and how does it relate to the system time constant? (10%)

2. Consider a dynamic system represented by the following transfer function.
   a. Derive the time response y(t) for a unit step input. (10%)
   b. From the response in b., explain it is a non-minimum phase system. (5%)

$$\frac{Y(s)}{R(s)} = \frac{s-4}{(s+2)^2}.$$

3. Consider a dynamic system modeled by the following set of differential equations,

$$\dot{x}_1 = -4x_1 + x_2,\ \dot{x}_2 = -3x_2 + x_3,\ \dot{x}_3 = -2x_3 + u,\ y = x_1.$$

   a. Let U(s)/(R(s)-Y(s))=Gc(s), where R(s) is an input and Gc(s) is a controller. Draw the block diagram representing the feedback control system and find the transfer function of Y(s)/R(s). (10%)
   b. Gc(s)=K(s+$\alpha$)/s For K>0 and $\alpha$>0, mark the area on K-$\alpha$ plane where the control system is stable. (15%)

4. 20%

Plot the Bode and Nyquist plot for the system with transfer function $G(s) = \dfrac{(s-10)}{s^2(s+10)}$.

5. 30% (2% for each matching pair)

Match each item in the left column to the corresponding item in the right column.

Format of the Answer: **(number) : Character, e.g. (1): A**

| | |
|---|---|
| (1). The property of a linear system in which the system response, *y(t)*, to an input *u(t)* leads to the response *Ay(t)* when the input is *Au(t)*. | A. Poles |
| (2). The case where the damping ratio $\zeta > 1$. | B. Final value law |
| (3). The law that states that if two inputs are scaled and summed and routed through a linear, time-invariant system, then the output will be identical to the sum of outputs due to the individual scaled inputs when routed through the same system. | C. Unity feedback |
| (4). The input to a control system often representing the desired output. | D. *S* plane |
| (5). The value that the output achieves after all the transient constituents of the response have faded. | E. Breakaway point |
| (6). A widely-used compensator that possesses one zero and one pole with the zero closer to the origin of the *s* plane. | F. Time constant |
| (7). The steady-state response of a system to a sinusoidal input signal. | G. Homogeneity |
| (8). All the zeros of a transfer function lie in the left-hand side of the s -plane. | H. Principle of Superposition |
| (9). A nonminimum phase system that passes all frequencies with equal gain. | I. Reference input |
| (10). A chart displaying the curves for the relationship between the open-loop and closed-loop frequency response. | J. Overdamped |
| (11). The frequency at which the frequency response has declined 3 dB from its low-frequency value. | K. Zeros |
| (12). The increase in the system gain when phase =-180° that will result in a marginally stable system with intersection of the -1+*j*0 point on the Nyquist diagram. | L. Linearized |
| (13). The point on the real axis where the locus departs from the real axis of the *s*-plane. | M. Frequency response |
| (14). The angle at which a locus leaves a complex pole in the *s*-plane | N. Phase-lag network |
| (15). A network that provides a positive phase angle over the frequency range of interest. | O. Phase-lead compensator |
| | P. Phase margin |
| | Q. Gain Margin |
| | R. Nichols chart |
| | S. Bode chart |
| | T. Phase-lead network |
| | U. Steady state |
| | V. Angle of departure |
| | W. Bandwidth |
| | X. Minimum phase |
| | Y. All-pass network |
| | Z. Phase-lag |