Problem I (100%). Consider a unit feedback control system with a plant transfer function

$$G(s)=\frac{8}{(1+s/8)s}$$

and a compensator $D(s)$ to be designed with output (equal to the plant input) of $U(s) = D(s)E(s)$, $E(s) = R(s) - Y(s)$, where R, Y, and E denote the reference input, plant output, and tracking error, respectively. The following design specifications are to be satisfied:

A. Phase margin PM ≥ 30°
B. Velocity error constant $K_v = 80$
C. Responses to sinusoidal inputs with frequencies higher than 100 rad/sec should be attenuated to less than 6% of their input value.
D. Tracking error for sinusoidal inputs with frequencies from 0 to 1 rad/sec should be less than 3%

(a) (10%) Draw a block diagram for the entire control system. Clearly indicate each signal and system.
(b) (10%) Determine the DC gain of the compensator so that $K_v = 80$.
(c) (20%) Carefully sketch the Bode plot of $G(s)$, with asymptotes, slopes, and critical frequencies clearly indicated.
(d) (20%) On the magnitude plot, determine the region thorough which the loop gain $D(s)G(s)$ should pass, as a sufficient condition for the control system to meet the specifications on sinusoidal inputs.
(e) (10%) Can introducing a lead compensator alone meet all the design specifications? Give your reasoning.
(f) (10%) Can introducing a lag compensator alone meet all the design specifications? Give your reasoning.
(g) (20%) Design a lead-lag compensator to meet all the design specifications.

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