1 Root Locus - 20 pts

For the open-loop pole-zero given below, sketch the root locus and find the break-in point.

Zeros: \( z_1 = -4 \quad z_2 = -2 \)

Poles: \( p_1 = 1 + j1 \quad p_2 = 1 - j1 \)

2 Root locus and stability - 25 pts

For the unity feedback system shown below, where

\[
G(s) = \frac{K(s^2 - 16)}{s^2 + 4}
\]

sketch the root locus and tell for what values of \( K \) the system is (marginally) stable and unstable.
3 Root locus sketch - 25 pts

For the unity feedback system shown in Problem 2, where

$$G(s) = \frac{K(s + 1)}{s(s + 6)(s + 10)}$$

Find $K$ to yield closed-loop complex poles with a damping ratio of 0.55. Does your solution require a justification of a second-order approximation? Explain.

4 PI controller - 30 pts

Design a PI controller to drive the step response error to zero for the unity feedback system as shown in Problem 2, where

$$G(s) = \frac{K}{(s + 1)(s + 2)(s + 10)}$$

without appreciably affecting transient response. The system operates with a damping ratio of 0.5. Compare the specifications of the uncompensated and compensated systems, i.e. percent overshoot, settling time.