Solution to Exam 3 April 17, 2001

1. Unstable if 0.5<Kc<1.0

2. a) $LM(G_c) = 20 \cdot \log(0.4) = -7.96 \cdot dB$

$\omega_{pc} := 1 \cdot \frac{rad}{sec}$

at ω_{pc} : $LM(G_p) = 10 \cdot dB$

$LM(G_c \cdot G_p) = (10 - 7.96) \cdot dB = 2.04 \cdot dB > 0 \cdot dB$

Thus not stabilized.

b) $K_u := 10^{-\frac{10}{20}}$ $K_u = 0.316$

$P_u := \frac{2 \cdot \pi}{1}$ $P_u = 6.283$

$K_c := \frac{K_u}{1.7}$ $K_c = 0.186$

$\tau_I := \frac{P_u}{2}$ $\tau_I = 3.142$

$\tau_D := \frac{P_u}{8}$ $\tau_D = 0.785$

3. $G(s) = \frac{1}{s+1} - \frac{2}{s+3} = \frac{(-s+1)}{(s+1)\cdot(s+3)}$

$MR(\omega) = \frac{1}{3} \cdot \frac{\sqrt{1+\omega^2}}{\sqrt{1+\omega^2} \cdot \sqrt{1+\frac{\omega^2}{9}}} = \frac{1}{\sqrt{9+\omega^2}}$

4. From Figure 5, phase crossover frequency is $\omega_{pc} := 10 \cdot \frac{rad}{sec}$

while the gain crossover frequency is $\omega_{gc} := 6.1 \cdot \frac{rad}{sec}$

Gain Margin : Let x be MR @ ω_{pc}

$20 \cdot \log(x) = -10 \cdot db$

$x := 10^{-\frac{10}{20}}$ $x = 0.316$

$GM := \frac{1}{x}$ $GM = 3.162$

Phase Margin: Phase shift @ ω_{gc} $\phi := -130 \cdot deg$

$PM := 180 \cdot deg + \phi$ $PM = 50 \cdot deg$

5. case 1: G7
case 2: G4
case 3: G1
case 4: G5

6. $\omega := \frac{2 \cdot \pi}{10} \cdot \frac{rad}{sec}$ $\omega = 0.628\ sec^{-1}$

$\phi := (-8 \cdot sec) \cdot \omega \cdot \frac{180 \cdot deg}{\pi}$ $\phi = -288 \cdot deg$

$MR := \frac{20}{10}$

$LM = 20 \cdot \log(MR) = 6.021 \cdot dB$