**Problem 1**

\[ G(s)H(s) = \frac{\frac{1}{100}}{s(s+5)(s+10)} \]

\( \omega_{n0} = 7.03 \ \text{rad/sec} \)

1.1 @ 7.03 rad/sec = -17.4 dB

So \( G_{m} = 17.4 \ \text{dB} \)

\( \omega_{m0} = 1.84 \ \text{rad/sec} \)

\( \pm @ 1.84 \ \text{rad/sec} = \pm 21^\circ \)

\( \phi_m = \arctan(-1.84) = +59^\circ \)

\[ K \text{ for Marginal Stability} \]

17.4 dB \( \approx 7.41 = K \)

See plots
Problem 2

\[ G(s)H(s) = \frac{K}{s(s+10)(s+2)} \]

\[ \omega_{n0} = 10.8 \text{ rad/sec} \]

\[ \text{Gain} = 10.8 \text{ rad/sec} = -14.8 \text{ dB} \]

\[ \omega_{n0} = 10.8 \text{ rad/sec} \]

\[ \angle = 3.7 \text{ rad} = -107^\circ \]

\[ \phi = \omega_{n0} = 3.7 \text{ rad} = -107^\circ \]

\[ \phi = -107^\circ - (-180^\circ) = 73^\circ = \phi \]

For marginal stability, \( y_{10} = 5.5 = K \)
\[ G(s)H(s) = \frac{K(\frac{2000}{s+5})}{s(s+3)(s+6)(s+100)} \]

\[ \omega_{ns} = 35.2 \text{ rad/sec} \]
\[ L = 35.2 \text{ rad/sec} \]
\[ GM = 37.1 \text{ dB} \]

\[ \omega_{cs} = 1.57 \text{ rad/sec} \]
\[ \phi = \omega_{cs} = -109 \]
\[ PM = -109 - (-180) = 71 = \bar{PM} \]

\[ K \text{ for marginal stability } K = 10^{37/20} = 71.61 = K \]
$$G(s)H(s) = \frac{K}{s^2(s+10)}$$

$\omega_n = 0.315 \text{ rad/sec}$

$\zeta = 0.315 = -182$

$PM = -182 - (-180) = -2 = 2\angle 0 \Rightarrow \text{UNSTABLE}$

$GM \Rightarrow \text{Cannot calculate as } \zeta \text{ Always } < 180$

$\Rightarrow \text{UNSTABLE for all gains}$
Bode for Problem 1

Bode for Problem 2
Bode for Problem 3

Bode for Problem 4