1. Consider the following parallel system, where $K > 0$, $a > 0$ and $b > 0$ are three system parameters. Find $K$, $a$ and $b$ such that the step response of the parallel system has 5% overshoot, 4.0 seconds 2% settling time, and $\lim_{t \to \infty} y(t) = 10$, where $y(t)$ is the unit system step response.

**Sol:**
2. Consider the following closed loop system

\[ \frac{s - 1}{s + 2} \rightarrow s + a \rightarrow \frac{s + a}{s + 2} \]

a) Find the closed loop characteristic equation
b) Calculate the breakaway points on the Root Locus
c) Calculate the stabilize range for \( a \) when the system is marginally stable.
d) Sketch the Root Locus for \( a > 0 \) in the next page

Sol:
3. Consider the closed-loop system shown in the figure below, where \( G_p(s) = \frac{1}{s(s+4)} \)

\[
\begin{align*}
G_c(s) & = \frac{K(s+p)}{s(s+2)} \\
G_p(s) & = \frac{1}{s(s+4)}
\end{align*}
\]

a) Design a phase-lead compensator \( G_c(s) = K \frac{s+p}{s+2} \) such that the closed-loop system has poles at \( s = -4 \pm 2j \). Use \( p = 6 \) in your design.

b) Without computing the location of the third pole, comment on the stability of the closed-loop system.

**Sol:**
4. Consider the closed-loop system shown in the figure below, where
\[ G_c(s) = K \frac{s+5}{s+10} \text{ and } G_p(s) = \frac{1}{s(s+1)} \]

a) For \( K = 1 \), sketch the Bode plots for the open-loop function.
b) From your plots, determine the gain and phase margin of the system.

Sol: