Some recollection of linear multivariable time-invariant systems \((G, K, C, M, R, U, Y)\) are all functions of \(s\).

Consider the following block diagrams:

\[
\begin{align*}
 G(s) U(s) &= Y(s) \\
 U(s) &= R(s) - K(s) Y(s) \\
 Y(s) &= \left(1 + G(s) K(s)\right)^{-1} G(s) R(s) \\
 &= G_f(s) R(s)
\end{align*}
\]

\(G_f\) is the closed-loop transfer function.

\[
\begin{align*}
 Y(s) &= \left(1 + G(s) C(s)\right)^{-1} G(s) C(s) R(s) \\
 &= G(s) R(s)
\end{align*}
\]
\[ G_1(s) \left( A_m + C(s) G_1(s) \right)^{-1} \]

and

\[ (iv) \]

\[ Y_M(s) = M(s) R(s) \]

\[ Y(s) = \left( \frac{1}{1 + G_1(s) C(s)} \right)^{-1} G(s) C(s) R(s) \]

In these diagrams \( K \) is a feedback \underline{\text{compensator}}, \( C \) is a \underline{\text{pre-compensator}}, \( M \) is a \underline{\text{reference model}} and \( G_1 \) is the \underline{\text{physical plant}}.

We refer to (iii) & (iv) as \underline{\text{series}}/\underline{\text{cascade model}} reference control and parallel model reference control respectively, and the design goal is to find \( C \) in these cases to achieve \( Y_m \approx Y \).
In case (iii) this amounts to choosing \( C \) such that
\[
(1 + G(s)C(s))^{-1} G(s)C(s) \approx 1
\]
and in case (iv) it is the matching problem:

Solve for \( C(s) \) such that
\[
(1 + G(s)C(s))^{-1} G(s)C(s) \approx M(s)
\]

Suppose \( p = m = 1 \) (SISO system). Then, in case (iii) this amounts to asking

\[
\frac{Gc}{1 + Gc} \approx 1
\]

\[
\iff \frac{G}{1/G + G} \approx 1
\]

which can be achieved if \( C(s) = 0 \to \infty \) (high gain).

We also recall the use of root-locus theory to design loops as in case (i), case (ii) — i.e. find \( K \) and \( C \) so as to achieve desired stability properties for the closed-loop system. It is clear that one