Feedforward control

1. Suppose objective now to track an arbitrary reference \( r(t) \). Assume it is differentiable.

2. Design a closed loop control system to reject disturbance and reduce system model uncertainty
   a. \( P \) or \( P-I \) etc.

3. Find a closed loop transfer function \( G_c(s) \) from command input \( r_1(t) \) to output \( y(t) \)

4. Define a feedforward controller \( G_{ff}(s) \) to be \( G_c^{-1}(s) \), such that \( R_1(s) = G_{ff}(s) \ R(s) \)

5. Check closed loop transfer function \( G_{YR}(s) \) from \( R(s) \) to \( Y(s) \)

6. \( G_{ff}(s) \) is likely not proper (numerator order is higher than denominator order). In implementation, improperness is implemented by differentiation. Separate \( G_{ff}(s) \) into proper and improper terms using long division.

7. How does \( G_{YR}(s) \) change if the open loop system model is not accurate? i.e. \( G_{ff}(s) \) is designed based on model but actual \( G_{YR}(s) \) is based on actual system.
   a. Effect in low frequency ?
   b. Effect in high frequency ?
   (depends on which controller you choose for the closed loop system)

Summary: When is feedforward a good idea, when is it a bad idea?