1. [25] Find the transfer function \( \frac{C(s)}{R(s)} \) as a ratio of simple polynomials in G’s and H’s.

![Block diagram](image)

2. [25] Find the state variable equations and the transfer function \( \frac{X_1(s)}{F(s)} \) for the mechanical system below.

![Mechanical system diagram](image)

3. [20] Thoroughly and concisely answer the following 3 questions in the space provided:

   a) What factors influence the choice of state variables in any system?

   b) If a pole is moved with constant real part, what will the unit step responses have in common?

   c) Name the three major design criteria for control systems.
A unity feedback control system is shown below:

\[
\frac{500}{s^2 + 15s + 125}
\]

a) find the natural frequency, damping ratio, and damped natural frequency of the closed loop system

b) determine the %OS, \(T_p\) and \(T_s\) for a step input to the closed loop system

c) sketch the unit step response of the closed loop system on the graph below