1. (25 pts) Given the block diagram in Figure 1, obtain the equivalent transfer function of $T_{set}$ to $T$.

![Block Diagram](image)

(Hint: the transfer function from $d$ to $T$ is: $\frac{D(1-GQ)}{GAB + (1+AB)(1-GQ)}$)

2. (25 pts) A set of reactions are described by the following equations:

$$\frac{dC_A}{dt} = -(k_{AB} + k_{AC})C_A + k_{BA}C_B$$

$$\frac{dC_B}{dt} = k_{AB}C_A - k_{BA}C_B + C_{Bin}$$

where $C_A$ and $C_B$ are concentrations of $A$ and $B$, while $C_{Bin}$ is the concentrations of $B$ in the feed. Obtain the transfer functions from $C_{Bin}$ to $C_A$, assuming zero initial conditions (e.g. all concentrations are perturbed variables). The constants are $k_{AB}=0.2$, $k_{BA}=0.7$, $k_{AC}=0.3$. 
3. (25 pts) For the block diagram shown in Figure 2, determine the range of values of $K_c$ for which the system is stable.

![Figure 2](image)

where,

$$G_c = K_c \left( \frac{2s + 1}{s + 1} \right)$$

$$G_v = \frac{1}{s + 1}$$

$$G_p = \frac{-2s + 1}{3s + 1}$$

4. (25 pts) For the control system given in Figure 3, design a PI controller for $G_c$ using the Ziegler-Nichols tuning rules.

![Figure 3](image)

5. Bonus (10pts): If one used a proportional controller with gain, $K_c = 4$, in the control system in Figure 3, determine the value of the steady state error for $T_{set} = 50$. 