(9) Find transfer func. from input to output for closed-loop system.

$$U(s) = K_p(R(s) - Y(s))$$
$$R(s) = U(s) - Y(s)$$
$$Y(s) = P(s)U(s)$$

$$\Rightarrow Y(s) = P(s)K_p(R(s) - Y(s))$$

$$\Rightarrow Y(s) = P(s)K_pR(s) - P(s)K_pY(s)$$

$$\Rightarrow Y(s) = \frac{P(s)K_pR(s)}{1 + P(s)K_p}$$

let $G(s) = \dfrac{K_pP(s)}{1+K_pP(s)} \Rightarrow Y(s) = G(s)R(s)$

$$P(s) = \frac{bT}{s+aT} \Rightarrow G(s) = \frac{\frac{bT}{s+aT}\cdot K_p}{1 + \frac{bT}{s+aT}\cdot K_p}$$

$\Rightarrow G(s) = \dfrac{bTK_p}{s+aT+bTK_p}$, let $\tau = \dfrac{1}{T(a+bK_p)}$

$\Rightarrow G(s) = \dfrac{\tau bTK_p}{\tau s + 1}$, $\left(\text{or } G(s) = \dfrac{\frac{bK_p}{a+bK_p}}{\frac{s}{T(a+bK_p)} + 1}\right)$

where $\tau = T^{-1}(a+bK_p)^{-1}$ is time const. and $K = \tau bTK_p$ is DC Gain