Control System

- Mason's gain formula $T = \sum_{K=1}^{K} \frac{P_K \Delta_K}{\Delta}$
- Unit step input response formulae

(a) Delay Time $t_d = \frac{1+0.7\xi}{\omega_n}$

(b) Rise

Time $t_r = \frac{\pi - \theta}{\omega_d}$, $\theta = \tan^{-1} \frac{\sqrt{1-\xi^2}}{\xi}$

(c) Maximum Overshoot

$$\% \, m_p = e^{\frac{-\xi\pi}{\sqrt{1-\xi^2}}} \times 100$$

(d) Settling Time:- $t_s = \frac{4}{\xi\omega_n}$ For 2% error

- Steady state error

$$e_{ss} = \lim_{s\to 0} s\,E(s) = \lim_{s\to 0} s\,R(s)\,\frac{1}{1+G(s)H(s)}$$

- The Steady state errors for type 0, type 1, Type 2 Unity feedback system are

Input System Type	Unit step	Unit Ramp	Unit Parabola
Type 0	$\frac{1}{1+K_p}$	∞	∞
Type 1	0	$\frac{1}{K_p}$	∞
Type 2	0	0	$\frac{1}{K_a}$

- Sensitivity of Control System

$$S_K^A = \frac{(\partial A \setminus A)}{(\partial K \setminus AK)}$$

- M–Circles Centre at $x = \frac{M^2}{1-M^2}$, $y = 0$ and Radius $r = \frac{M}{1-M^2}$

N–Circles:- Centre at $x = -\frac{1}{2}$, $y = \frac{1}{2N}$ Radius $r = \frac{1}{4} + \frac{1}{4N^2}$

- Angle of Asymptotes $= \frac{(2q+1)180}{P-Z}$

- Angle of Departure $\phi_D = 180 + \phi$ & Angle of Arrival— $\phi_A = 180 - \phi$ where, $\phi = \sum \phi_Z - \sum \phi_P$

- Gain margin, $GM = \frac{1}{|G(\omega)H(\omega)|_{\omega=\omega pc}}$, phase margin, $\phi_{pm} = 180 - \arg G(\omega)H(\omega)|_{\omega=\omega gc}$

- Transfer matrix =

$$\frac{Y(s)}{U(s)} = C(sI - A)^{-1}B + D$$

- System is completely controllable if rank of matrix Q_c is equal to order of the system($r = n$) in

$$Q_c = \left[B : AB : A^2B \ldots\ldots\ldots\ldots A^{n-1}B\right]$$

- System will be completely observable if rank of Q_0 equal to order of matrix ($r = n$) in

$$Q_o = C^T : A^T C^T : \left(A^T\right)^2 C^T : \ldots\ldots\ldots\ldots : \left(A^T\right)^{n-1} C^T$$