Space for marks	Question Number	

steady state error for step input

$e_{ss1} = \frac{A_1}{1+K_P} - ①$

for ramp input $e_{ss2} = \frac{A_2}{K_V} - ②$

for parabolic input

$e_{ss3} = 1/0.5 = 2$

total steady state error = 2

Q2. (c) $\frac{Y(s)}{U(s)} = \frac{2s^3 + s^2 + s + 2}{s^3 + 4s^2 + 5s + 2}$

$\dddot{y} + 4\ddot{y} + 5\dot{y} + 2y = 2\dddot{u} + \ddot{u} + \dot{u} + 2u$

$\Rightarrow ①$

$\beta_0 = b_0 = 2, \beta_1 = b_1 - a_1\beta_0 = -7$

$\beta_2 = b_2 - a_1\beta_1 - a_2\beta_0 = 19$

$\beta_3 = b_3 - a_1\beta_2 - a_2\beta_1 - a_3\beta_0 = -43$

output eqn.

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -2 & -5 & -4 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} -7 \\ +19 \\ -43 \end{bmatrix} U$$

$$y = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + 2U$$

Q 5 (b) max. deflection = $d_m = \frac{3P}{16Et^3} R^4(1-\nu^2)$, But $d_m = t/3$

$t/3 = \frac{3P}{16Et^3} R^4(1-\nu^2) \Rightarrow t^4 = \frac{9P}{16E} R^4(1-\nu^2)$

$t = 0.408 \times 10^{-3}\, m = 0.408\, mm$

$f_n = \frac{2.5t}{\pi R^2}\left[\frac{E}{3P}(1-\nu^2)\right]^{1/2}$

$= \frac{2.5 \times 0.408 \times 10^{-3}}{\pi \times 6.25}\left[\frac{200 \times 10^9}{3 \times 7800(1-0.28^2)}\right]^{1/2}$

$= 35.66\, kHz$