2/C Riley Thorham
2/C Christian Johnson. | Controls Pre-Lab Quiz

Table 1

① $K_{pot} = \frac{V_i(s)}{\theta_i(s)} = \frac{10}{10\pi} = \frac{1}{\pi}$

* 5 turns toward pos. 10 V or neg 10 V = Volt. Δ of 10 V. Divide V. Δ by angular displacement. But?

② $\frac{K_1}{s+a}$ $G_{pamp}(s) = \frac{K_1}{s+a}$ $\frac{E_a(s)}{V_p(s)} = \frac{150}{s+150}$

④ Motor $\frac{K_m}{s(s+a_m)} \rightarrow \frac{.8}{s(s+1.32)}$

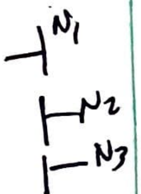
$\frac{\theta_m(s)}{E_a(s)} = \frac{K_t/(R_a J_m)}{s\left[s+\frac{1}{J_m}\left(D_m+\frac{K_t K_b}{R_a}\right)\right]} \rightarrow \frac{1/(5*.25)}{s\left[s+\frac{1}{.25}\left(.13+\frac{1.1}{5}\right)\right]} = \frac{.8}{s(s+1.32)}$

3 gears?

$J_m = .05 + 5\left(\frac{50}{250}\right)^2 = .25$

dest for source gears... $D_m = .01 + 3\left(\frac{50}{250}\right)^2 = .13$

⑤ $K_g = \frac{N_1}{N_2} = \frac{50}{250} = 1/5$



Dest/source

$G_{mo} = \frac{\theta_o(s)}{E_a(s)} =$ * transfer fcn by gear ratio.

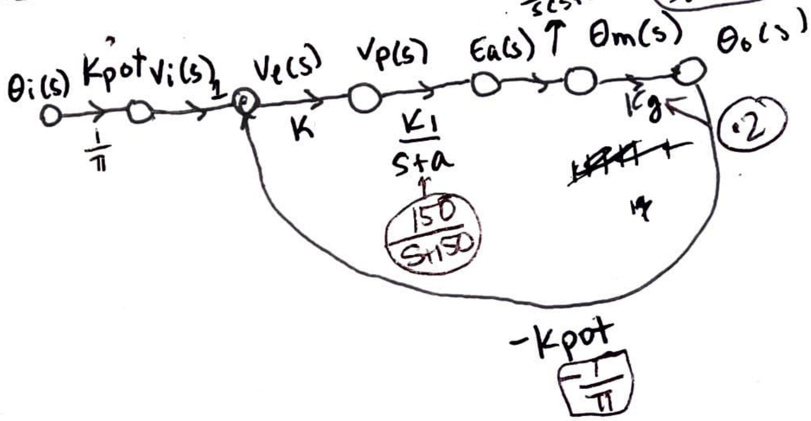
$\frac{\theta_m(s)}{E_a(s)} * .2 = \frac{.16}{s(s+1.32)}$

⑥

Parameters	K_{pot}	K	a	K_m	a_m	K_g
Configuration	$1/\pi$	?	150	.8	1.32	1/5

$\frac{K_m}{s(s+a_m)}$ $\frac{.8}{s(s+1.32)}$

⑦ $T(s) = \frac{\theta_o(s)}{\theta_i(s)}$:



7 (cont) Controls Pre-lab Quiz 4

(7) T_K $\left\{ T_1: K_{pot} \cdot K \cdot \frac{K_1}{s+a} \cdot \frac{K_m}{s(s+a_m)} \cdot K_g \right.$ (Feed Forward)

Loops $L_1 : K \cdot \frac{K_1}{s+a} \cdot \frac{K_m}{s(s+a_m)} \cdot K_g \cdot -K_{pot}$

$\Delta = 1 - L_1$

$\Delta_K \Rightarrow T_1 \rightarrow \Delta_1 = 1$

$$\frac{\theta_o(s)}{\theta_i(s)} = \frac{1}{\Delta} = \frac{1}{1-L_1} = \cancel{\frac{1}{1-K_{pot} \cdot K \cdot \frac{K_1}{s+a}}}$$

$$\frac{1}{1-\left(K \cdot \frac{K_1}{s+a} \cdot \frac{K_m}{s(s+a_m)} \cdot K_g \cdot -K_{pot}\right)} = \frac{1}{1-K\left(\frac{150}{s+150} * \frac{.8}{s(s+1.32)} * .2 * -\frac{1}{\pi}\right)}$$

$$= \frac{1}{1-\frac{150K}{s+150} * \frac{.8K}{s(s+1.32)} * .2K - \frac{K}{\pi}}$$

$$1 - \frac{240K}{(s+150)^2} - \frac{K}{\pi}$$

$(\pi - 240K\pi - K)$

$$\cancel{\frac{(s+150)^2 - 240K\pi - (s+150)^2 K}{\pi(s+150)^2}}$$

$$\cancel{\frac{1}{\pi - \frac{240K\pi}{(s+150)^2} - K}} = \cancel{\frac{1}{(\pi-K)(s+150)^2 - 240K\pi}}$$

$$\cancel{\frac{1}{(\pi-K)(s^2+300s+22500) - 240K\pi}} = \cancel{\frac{1}{(\pi-K)s^2 + (300\pi - 300K)s + (22500)(\pi-K) - 240K\pi}}$$

$$\cancel{= \frac{1}{(\pi-K)s^2 + (300\pi - 300K)s + (22500\pi - 22500K - 240K\pi)}}$$

$$\frac{1}{1-K\frac{150}{s+150} * \frac{.8}{s(s+1.32)} * .2 * -\frac{1}{\pi})} \quad \boxed{\frac{s(s+1.32)(s+150)}{s^3+151.32s^2+198s+7.63K}}$$

Controls Pre-Lab
Quiz 4

(8) Routh-Hurwitz Table to find range of controller (K) that makes antenna system stable.

$$\frac{V_p(s)}{V_e(s)} = K$$

if all elements in the 1st column are positive.

s^2	$(\pi - K)$	$122500\pi - 22500K - 240K\pi$	$\emptyset$
s^1	$300\pi - 300K$	$\emptyset$	$\emptyset$
s^0			

$$\frac{s(s+1.32)(s+150)}{s^3 + 151.32s^2 + 198s + 7.63K}$$

	s^3	1	198	$\emptyset$
$b_1, b_2 \rightarrow$	s^2	151.32	$7.63K$	$\emptyset$
$c_1, c_2 \rightarrow$	s^1	A	B	$\emptyset$
$d_1\ d_2$	s^0	d_1	d_2	

C_1 A: $\dfrac{\begin{vmatrix} 1 & 198 \\ 151.32 & 7.63K \end{vmatrix}}{151.32} = \dfrac{7.63K - 29961.36}{151.32}$

C_2 B: $\dfrac{\begin{vmatrix} 1 & \emptyset \\ 151.32 & \emptyset \end{vmatrix}}{151.32} = \emptyset$

S_3	1	198	$\emptyset$
S_2	151.32	$7.63K$	$\emptyset$
S_1	$\frac{7.63K - 29961}{151.32}$	$\emptyset$	$\emptyset$
S_0	$-7.63K$	$\emptyset$	$\emptyset$

d_1: $\dfrac{\begin{vmatrix} 151.32 & 7.63K \\ \frac{7.63K-29961}{151.32} & \emptyset \end{vmatrix}}{\frac{7.63K - 29961}{151.32}} = -7.63K$

d_2: $\dfrac{\cancel{\begin{vmatrix} & \\ & \end{vmatrix}}}{\frac{7.63K - 29961}{151.32}} = \emptyset$

$$\frac{7.63K - 29961}{151.32} > \emptyset$$

$$\frac{7.63K}{7.63} > \frac{29961}{7.63}$$

$$K < 3926.7$$

$$-7.63K > 0$$

$$K > \emptyset$$

$\therefore$ Stability
$0 < K < 3926.7$