Group Members			
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By filling out the names above, the group members acknowledge that a) they have jointly authored this submission, b) this work represents their original work, c) that they have not been provided with nor examined another person's assignment, either electronically or in hard copy, and d) that this work has not been previously submitted for academic credit.			

LAB 2. SECOND-ORDER SYSTEM IDENTIFICATION AND ANALYSIS

ASSIGNED DATA

For easily referencing it, the Assigned Data has been placed at the start of this document.

On your pre-lab and post-lab submissions, always include this page at the beginning of the document.

Select your lab session:		☐ morning lab; ☒ afternoon lab; ☒ Tue; ☐ Wed; ☐ Thu
CourseBook Group Number		45
Assigned plant number (*Plant ¿ = CourseBook GroupNumber ¿*		45
Plant parameters:	a	2
	b	5
	T	100
	K_i	330

The green highlighting present in this document is meant to draw your attention to things that need to be done.

Pre-Lab

Question 1

By reducing block diagram rules:

$$\begin{aligned}
\text{Let } H(S) &= \frac{K_i}{s} \times \frac{bT}{s+aT} \\
&= \frac{K_i bT}{s(s+aT)} \\
G(S) &= \frac{H(S)}{1+H(S)} \\
&= \frac{\frac{K_i bT}{s(s+aT)}}{1+\frac{K_i bT}{s(s+aT)}} \\
&= \frac{\frac{K_i bT}{s(s+aT)}}{\frac{s(s+aT)+K_i bT}{s(s+aT)}} \\
&= \frac{K_i bT}{s(s+aT)} \times \frac{s(s+aT)}{s(s+aT)+K_i bT} \\
&= \frac{K_i bT}{s(s+aT)+K_i bT} \\
&= \frac{K_i bT}{s^2+aTs+K_i bT}
\end{aligned}$$

Question 2

Using the standard second order system.

$$\begin{aligned}
G(S) &= \frac{\omega_n^2}{s^2+2\zeta\omega_n s+\omega_n^2} \\
\omega_n &= \sqrt{K_i bT} \\
2\zeta\omega_n &= aT \\
\zeta &= \frac{aT}{2\omega_n} \\
&= \frac{aT}{2\sqrt{K_i bT}}
\end{aligned}$$

Question 3

With OS in its decimal value.

$$
\begin{aligned}
T_p &= \frac{\pi}{\omega_n \sqrt{1-\zeta^2}} \\
OS &= e^{\frac{-\zeta\pi}{\sqrt{1-\zeta^2}}} \\
\ln OS &= \frac{-\zeta\pi}{\sqrt{1-\zeta^2}} \\
\ln OS \times \sqrt{1-\zeta^2} &= -\zeta\pi \\
\ln^2 OS \times (1-\zeta^2) &= \zeta^2\pi^2 \\
\ln^2 OS - \ln^2 OS\zeta^2 &= \zeta^2\pi^2 \\
\ln^2 OS &= \zeta^2(\ln^2 OS + \pi^2) \\
\zeta &= \sqrt{\frac{\ln^2 OS}{\ln^2 OS + \pi^2}}
\end{aligned}
$$

Question 4a

$$
\begin{aligned}
H_{open}(S) &= (K_p \times G(S) + D(S)) \times K \\
&= G(S) \\
&= \frac{K_i bT}{s^2 + aTs + K_i bT}
\end{aligned}
$$

Question 4b

$$
\begin{aligned}
H_{closed}(S) &= \frac{H_{open}(S)}{1 + H_{open}(S)} \\
&= \frac{\frac{K_i bT}{s^2+aTs+K_i bT}}{1 + \frac{K_i bT}{s^2+aTs+K_i bT}} \\
&= \frac{\frac{K_i bT}{s^2+aTs+K_i bT}}{\frac{s^2+aTs+K_i bT+K_i bT}{s^2+aTs+K_i bT}} \\
&= \frac{K_i bT}{s^2 + aTs + K_i bT} \times \frac{s^2 + aTs + K_i bT}{s^2 + aTs + 2K_i bT} \\
&= \frac{K_i bT}{s^2 + aTs + 2K_i bT}
\end{aligned}
$$

Question 4c

$$H_d(S) = \frac{K}{1 + K \times (R(S) + K_p \times G(S))}$$
$$H_d(S) = \frac{1}{1 + G(S)}$$
$$H_d(S) = \frac{1}{1 + \frac{K_i bT}{s^2 + aTs + K_i bT}}$$
$$H_d(S) = \frac{1}{\frac{s^2 + aTs + K_i bT + K_i bT}{s^2 + aTs + K_i bT}}$$
$$H_d(S) = \frac{s^2 + aTs + K_i bT}{s^2 + aTs + 2K_i bT}$$

Question 5

Assigned Parameter Value	Select Range Value	ACS13016 Display Value
2	-	20
5	-	50
330	10	33