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Addis Ababa Institute of Technology
School of Chemical and Bio-Engineering
CBEg 6142 Advanced Process Control

Assignment II Submission Date: ______________

1. A proportional controller is used to control the level of liquid in a flash separator by manipulating the outlet flow of the bottom stream. The following transfer functions apply for the liquid level control system:

$$G_p = \frac{1}{6s+1} \qquad G_m = \frac{1}{s+1} \qquad G_v = \frac{1}{2s+1}$$

a. Determine the range of values for the controller gain K_c that makes the liquid level control system stable.

[5 marks]

b. Calculate the controller settings using Ziegler-Nichols methods for:

i. Proportional (P)-only controller.

[2 marks]

ii. Proportional-and-Integral (PI) controller.

[3 marks]

c. For the values given in **part (b)**, determine the offset if a P-only control is used.

[5 marks]

2. The dynamic behavior of a process is approximated a second order model with manipulated variable *M*, disturbance variable *D* and output variable *Y*.

$$Y(s) = \frac{5}{(10s+1)(3s+1)} M(s) + \frac{1}{(10s+1)(3s+1)} D(s)$$

The measurement (transmitted) and the control valve can be estimated by first order transfer functions:

$$G_V = \frac{0.15}{0.5s+1}$$

$$G_m = \frac{1}{s+1}$$

a. Construct a feedback control system using block diagram.

[3 marks]

b. Conduct stability analysis and determine the range of K_c for which a feedback control system with proportional controller will be stable.

[7 marks]

c. If an offset of 5% both for servo and regulator problem is tolerated, analyze and decide whether a proportional controller with Ziegler-Nichols setting can provide a satisfactory performance.

[5 marks]

d. If offset is not tolerated, propose a controller and its Ziegler-Nichols setting with appropriate justification.

[5 marks]

3. The block diagram of a feedback control system is shown in **Figure Q4**.

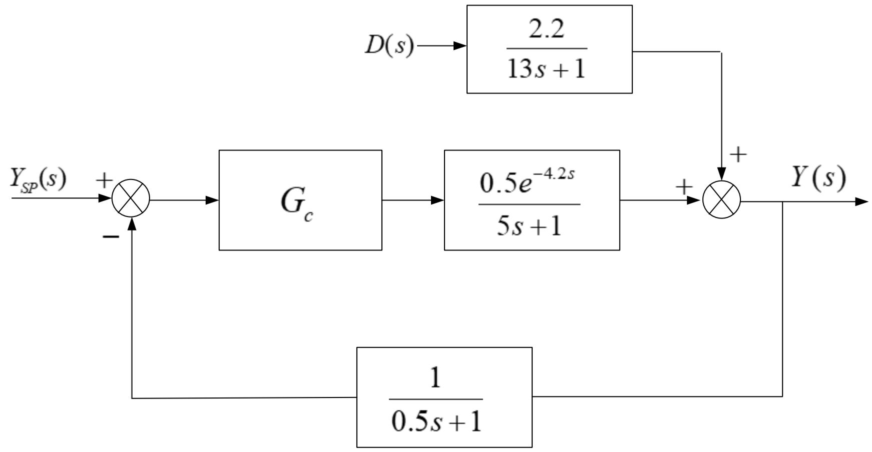

Figure Q4. Feedback control system

a. Determine the range of K_c for which the feedback control system in **Figure Q4** is stable.

[5 marks]

b. Determine the Tyreus-Luyben and Zeigler-Nichols settings of a PI and PID controller and compare the two settings for servo and regulator problems.

[10 marks]

TABLE 1: Ziegler- Nichols settings

	Kc	τ_I	τ_D
P	$\frac{K_{cu}}{2}$		
PI	$\frac{K_{cu}}{2.2}$	$\frac{T_u}{1.2}$	
PID	$\frac{K_{cu}}{1.7}$	$\frac{T_u}{2}$	$\frac{T_u}{8}$

TABLE 2: Tyreus-Luyben

	Kc	τ_I	τ_D
PI	$0.31K_{cu}$	$2.2T_u$	
PID	$0.45K_{cu}$	$2.2T_u$	$T_u / 6.3$