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CONFIDENTIAL

SET A

UNIVERSITI KUALA LUMPUR
Malaysia France Institute

FINAL EXAMINATION
SEPTEMBER 2014 SESSION

SUBJECT CODE	:	**FAB38404**
SUBJECT TITLE	:	**PROCESS CONTROL**
LEVEL	:	**BACHELOR**
TIME / DURATION	:	**9.00 AM – 12.00 PM (3 HOURS)**
DATE	:	**8 JANUARY 2015**

INSTRUCTIONS TO CANDIDATES

1. **Please read the instructions given in the question paper CAREFULLY.**
2. **This question paper is printed on both sides of the paper.**
3. **Please write your answers on the answer booklet provided.**
4. **Answer should be written in blue or black ink except for sketching, graphic and illustration.**
5. **This question paper consists of SIX (6) questions. Answer FIVE (5) questions only.**
6. **Answer all questions in English.**

THERE ARE 7 PAGES OF QUESTIONS, EXCLUDING THIS PAGE.

Question 1

(a) Explain the terms controlled variable (CV), measured variable (MV), set point (SP) and error (E) in feedback control system

(4 marks)

(b) Define SISO system and MIMO system. Give an example each.

(4 marks)

(c) The preliminary process designs have been prepared for the continuous-flow stirred-tank chemical reactor system as shown in **Figure 1**. The key variables to be controlled are composition, temperature and liquid level. Disturbance occurs in the feed temperature and composition. Answer the following questions:

i. Determine which sensors and final control elements are required so that the important variables can be controlled. Using a standard P&ID symbols, sketch on the figure where they should be located.

(8 marks)

ii. Describe how the equipment capabilities should be determined

(2 marks)

iii. Draw the control signal line from which measured variable should be controlled by adjusting the selected manipulated variable

(2 marks)

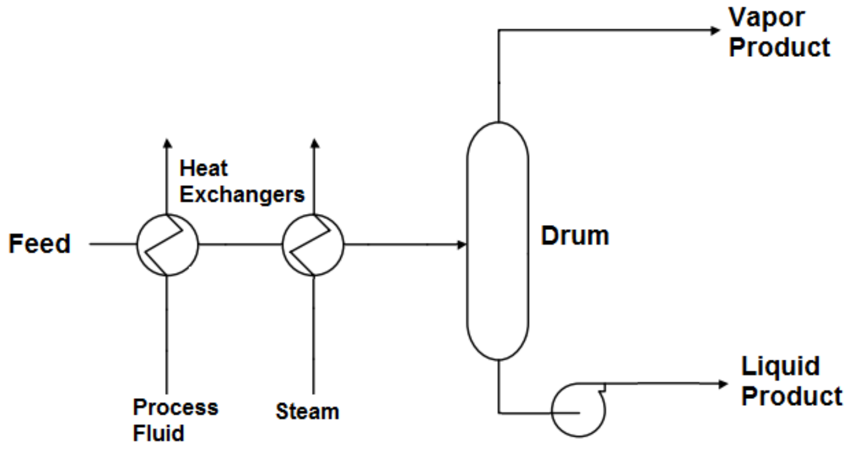

Figure 1: The continuous-flow stirred-tank chemical reactor system

Question 2

(a) Briefly explain the **five (5)** process control objectives

(5 marks)

(b) Describe the terms control configuration in design elements of control system and list **three (3)** types of control configurations.

(5 marks)

(c) Consider the non-interacting tank system shown in **Figure 2**. Assume that the flow rate of an effluent stream from a tank is proportional to the hydrostatic liquid pressure that causes the flow of liquid. The level of liquid in tank 2 affect the effluent flow rate from tank 1. The cross-sectional area of tank 1 is A_1 (ft^2) and of tank 2 is A_2 (ft^2). The flow rates F_1, F_2 and F_3 are in ft^3/min.

i. Develop the mathematical model for the system.

(8 marks)

ii. List the state variables for the system and type of balance equations used

(2 marks)

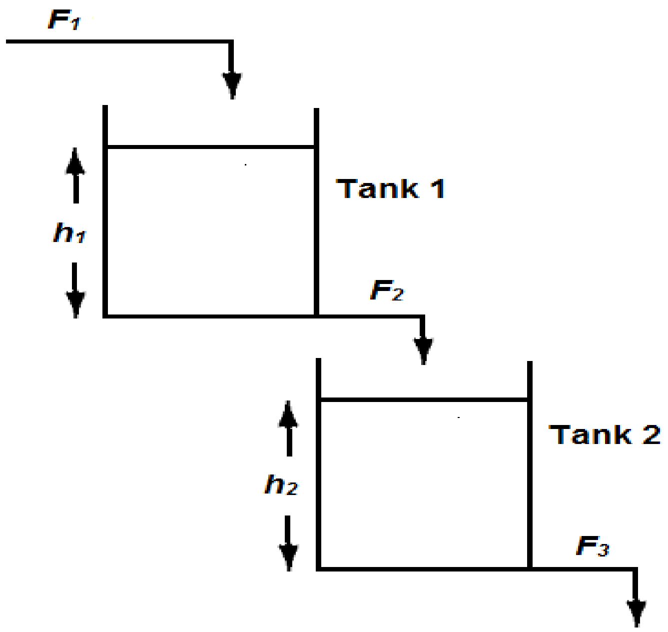

Figure 2: Non-interacting tank system

Question 3

Consider the stirred tank heater system shown in **Figure 3**. A liquid enters the tank with a flow rate, F_i (ft^3/min) and a temperature, T_i (°F) where it is heated with steam (flow rate F_{st} lb/min). F_o and T_o be the flow rate and temperature of the stream leaving the tank respectively.

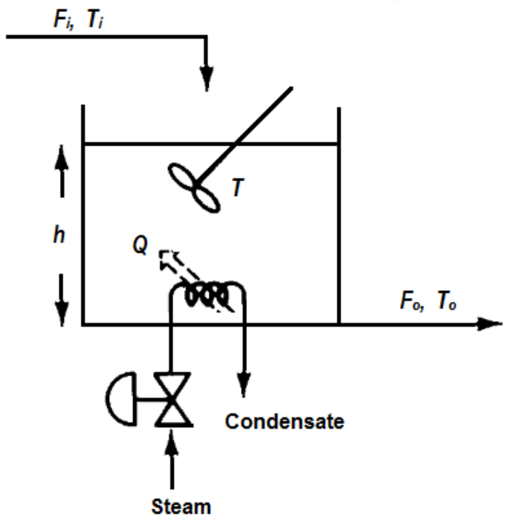

Figure 3: The stirred tank heater system

(a) Based on **Figure 3**, answer the following:

i. State **two (2)** control objectives for the system.

(2 marks)

ii. Name **two (2)** external disturbances that will affect the operation of the system

(2 marks)

iii. Name **two (2)** available manipulated variables for the control of the tank in the presence of disturbances.

(2 marks)

(b) For the system in **Figure 3**, construct two different feedback control configurations that will satisfy the control objectives in the presence of disturbances.

(4 marks)

(c) Describe the steps that you would go through in designing a control system for maintaining the level of the liquid in a stirred tank at a desired value.

(5 marks)

(d) Define the term inferential control configuration and feedforward control configuration. Which one is preferable for the above systems

(5 marks)

Question 4

(a) Discuss the differences between P and PI controller in term of transient response and steady state response.

(5 marks)

(b) A Proportional Derivative (PD) controller has a proportional gain, K_p = 2, derivative gain, K_D = 2 second and controller output, *CO* = 40%. **Figure 4** shows the error input graph which can be divided into three (3) segments; 0 – 2 sec, 2 – 4 sec and 4 – 6 sec. Calculate for each segment, the error, e_p and the new controller output, *CO*. Plot the graph of Controller Output, *CO* (%) versus time, *t (sec)*.

(15 marks)

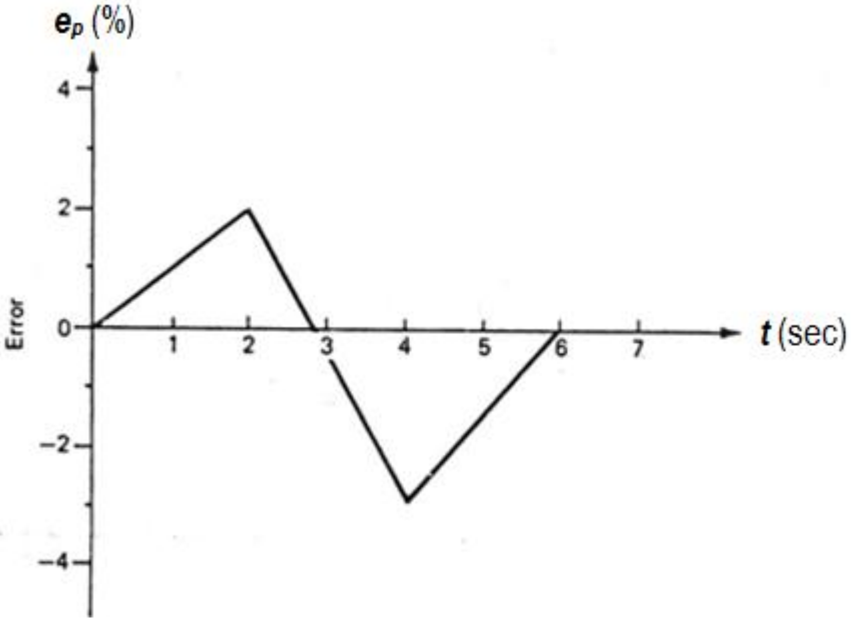

Figure 4: The error input graphs

Question 5

(a) **Figure 5** shows the dynamic behavior of first order plus dead time (FOPDT) on gravity drained tank response.

i. Explain the terms Dead Time (Θp), Time Constant (τp) and Steady State Process Gain (K_p) and show the terms on the graph.

(4 marks)

ii. Calculate the value for dead time, time constant and process gain

(3 marks)

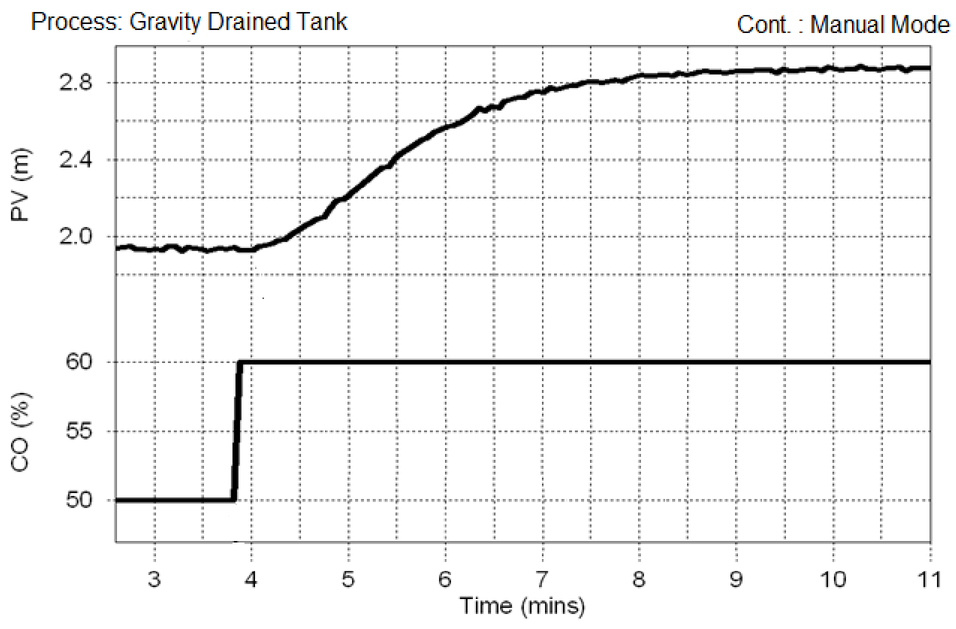

Figure 5: Gravity Drained Tank response

(b) Temperature control system has a temperature response that span form 120°C to 350°C. Given the proportional band of the controller is 60%

i. Calculate the maximum and minimum process variable (PV_{max}, PV_{min}) if the set point is set to be 200°C when the error (E) is zero and the controlled variable (CV) is 50%. Assuming CV range is 0-100%. Show the result in CV versus PV graph.

(7 marks)

ii. Calculate the proportional gain, Kp for the system

(2 marks)

iii. If the process variable decreases to 180°C, calculate the error incurred over the total temperature span and determine the new controlled variable (CV).

(4 marks)

Question 6

(a) Describe the Ziegler-Nichols tuning methodology.

(4 marks)

(b) Using the Cohen-Coon suggested setting, find the value for the proportional (K_c), integral (τ_I), derivative (τ_D) controller if the process reaction curve gain, G_{PRC} if given by

$$G_{PRC} = \frac{10e^{-0.1s}}{0.5s+1}$$

The Cohen-Coon suggested setting parameters given as follow:

$$K_c = \frac{1}{K}\frac{\tau}{t_d}\left(\frac{4}{3}+\frac{t_d}{4\tau}\right); \quad \tau_I = t_d\,\frac{32+6t_d/\tau}{13+8t_d/\tau}; \quad \tau_D = t_d\,\frac{4}{11+2t_d/\tau}$$

(6 marks)

(c) **Figure 6** shows the oscillation curve of process response after tuning the process gain. **Table 1** shows the Ziegler-Nichols tuning correction. Based on **Figure 6** and **Table 1**, answer the following :

i. Determine ultimate gain, K_u and ultimate period, T_u

(2 marks)

ii. Calculate loop tuning constant K_p, T_i and T_D

(3 marks)

iii. Calculate the proportional band, Integral gain and Derivative gain

(3 marks)

iv. Write the controller output equation of PID after tuned.

(2 marks)

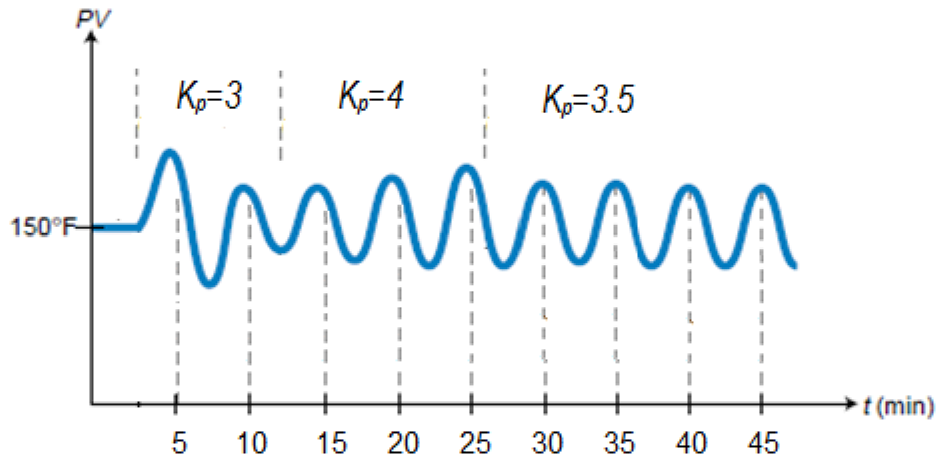

Figure 6: The oscillation curve of process response after tuning the process gain

Table 1: Ziegler-Nichols closed-loop tuning corrections

Type of Controller	Loop Tuning Constant	Tuning Equation
Proportional-Integral-Derivative (PID)	K_P T_I T_D	$K_P = (0.6)(K_{PU})$ $T_I = T_U / 2$ $T_D = T_U / 8$
Note : $\%PB = 1/K_P$; $K_I = 1/T_I$; $K_D = T_D$		

END OF QUESTION