CONFIDENTIAL

SET A

UNIVERSITI KUALA LUMPUR
Malaysia France Institute

FINAL EXAMINATION
JANUARY 2014 SESSION

SUBJECT CODE	**:**	**FAB 38404**
SUBJECT TITLE	**:**	**PROCESS CONTROL**
LEVEL	**:**	**BACHELOR**
TIME / DURATION	**:**	**(3 HOURS)**
DATE	**:**	

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 TWO (2) sections. Section A and B. Answer all questions in Section A. For Section B, answer two (2) questions only.**
6. **Answer all questions in English.**

THERE ARE 7 PAGES OF QUESTIONS, EXCLUDING THIS PAGE AND APPENDIX.

SECTION A (Total: 40 marks)

INSTRUCTION: Answer ALL questions.
Please answers all in answer booklet provided.

Question 1

Figure 1 shows a non-interacting process plant in industry.

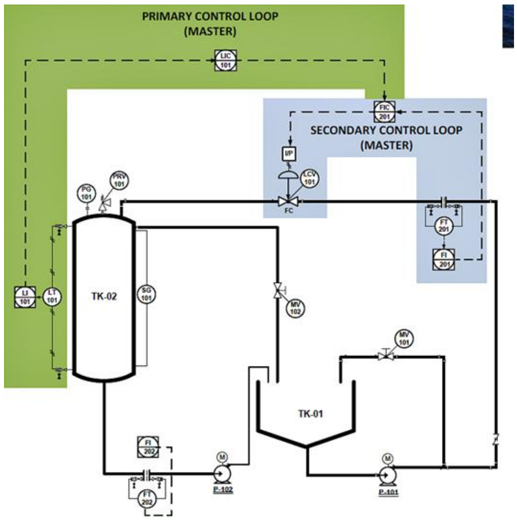


Figure 1: Non-interacting process plant

(a) Describe the control system as in **Figure 1**.

(2 marks)

(b) Explain the role of primary control loop.

(2 marks)

(c) Explain the role of secondary control loop.

(2 marks)

(d) State **one** (1) advantage of this type of control system refer to **Figure 1**.

(2 marks)

(e) Compare between batch and continuous process control

(4 marks)

(f) State **four (4)** important manipulated variables in process control

(4 marks)

(g) Explain the relationship between time constant and steady state response for first order process plant.

(2 marks)

(h) Compare the characteristic of response between first order and second order process plant.

(2 marks)

Question 2

Figure 2 shows a single tank for heating process. Answer the following questions based on this **Figure 2**.

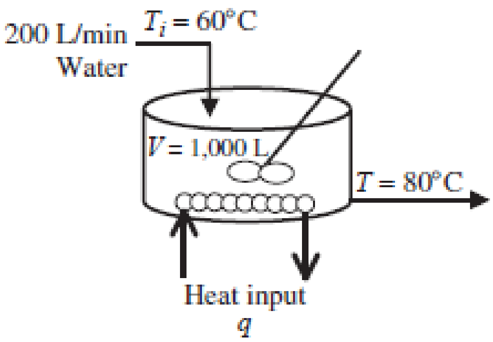


Figure 2: Water Heating Process

(a) Develop a transfer function relating the tank outlet temperature to changes in the inlet temperature.

(7 marks)

(b) Develop a transfer function relating the tank outlet temperature to changes in the inlet heat input

(7 marks)

(c) Determine the response of the outlet temperature of the tank to a step change in the inlet temperature from 60 ° C to 70 ° C. Sketch a plot of Temperature output response versus.

(6 marks)

SECTION B (Total: 60 marks)

INSTRUCTION: Answer TWO (2) questions only.
Please answers all in answer booklet provided.

Question 3

Figure 3 shows temperature response of heating process. Answer all questions below based on **Figure 3** and **Table 1.**

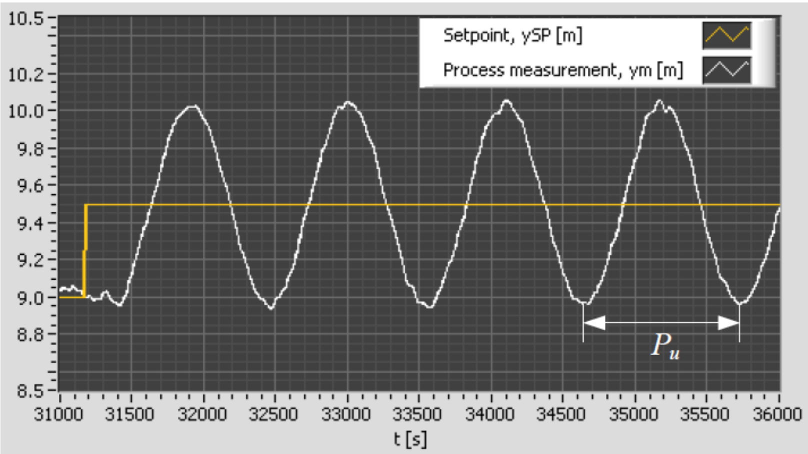


Figure 3: Temperature response chart

Table 1: Temperature response table

	K_p	T_i	T_d
P controller	$0.5K_{pu}$	∞	0
PI controller	$0.45K_{pu}$	$\frac{P_u}{1.2}$	0
PID controller	$0.6K_{pu}$	$\frac{P_u}{2}$	$\frac{P_u}{8} = \frac{T_i}{4}$

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

(4 marks)

(b) Explain the error step input and disturbance rejection phenomena in process control system by sketching graph output vs. time.

(4 marks)

(c) Briefly explain the procedure for tuning closed loop Ziegler Nichols (Z-N) Method.

(4 marks)

(d) Compare the difference between Ziegler Nichols and Cohen and Coon (C-C) tuning procedure.

(5 marks)

(e) Explain the proportional band and its relation to system response. Elaborate the procedure of adjusting value of proportional band until time Period is achieved.

(5 marks)

(f) If the proportional band is 50%, calculate the proper optimum value for P, PI and PID controller.

(8 marks)

Question 4

Consider the following chemical mixing process as shown in **Figure 4.** Two process streams are mixed to produce one of the feeds for the chemical reactor. After mixing, the blended stream is fed to a heating vessel before being sent to the reactor. The process is running along at steady state. The concentration of sugar in stream 1 is 1 g/L and in stream 2 is 4 g/L.

Answer all question below based on **Figure 4.**

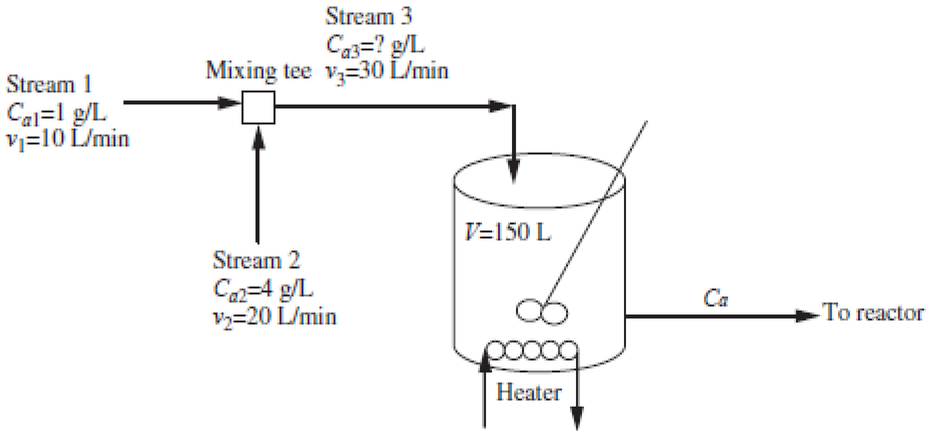


Figure 4: Chemical mixing process flow diagram showing operator-induced transient

(a) State **one (1)** example for this chemical mixing and heating process in industry.

(2 marks)

(b) Using mass balance principle, calculate the sugar concentration input Ca3 into the heating tank.

(4 marks)

(c) At 3:00 P.M, the shift changes at the plant. The new operator changes the flow rates of the two streams. Stream 1 is switched to 20 L/min, and stream 2 is switched to 10 L/min. Calculate the new sugar concentration input Ca3 into the heating tank.

(4 marks)

(d) From the answer in (c) and given the liquid input temperature is 45 °C, Calculate the heater power input in order to raise the output liquid temperature to 80°C.

(6 marks)

(e) Develop the first order transfer function to relate the sugar concentration output Ca (s) from the heating tank to sugar concentration input Ca3 (s) into the heating tank

(8 marks)

(f) If the step input sugar concentration Ca3 (s) = 1g/L, calculate the inverse transform from question 2(e) and plot the exit concentration from the heating vessel (use graph paper).

(6 marks)

Question 5

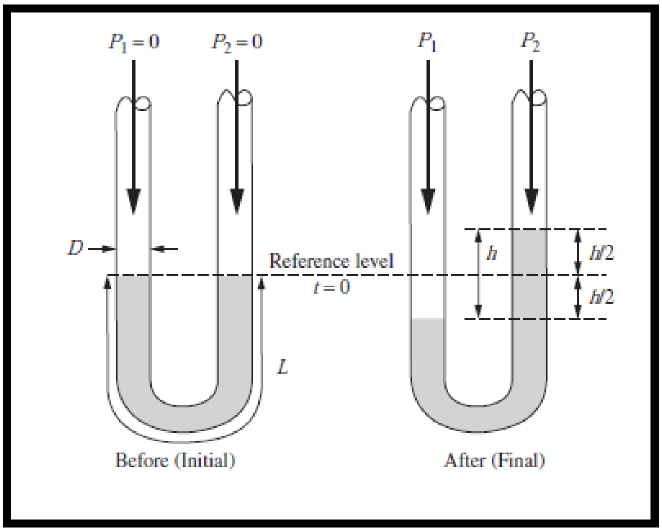


Figure 5: Manometer system

(a) **Figure 5** shows Manometer system. Answer all questions below based on **Figure 5**.

i. Using Bernoulli principle derive step input X(s) for manometer system.

(3 marks)

ii. Develop second order system transfer function to relate output Y(s) to step input X(s).

(15 marks)

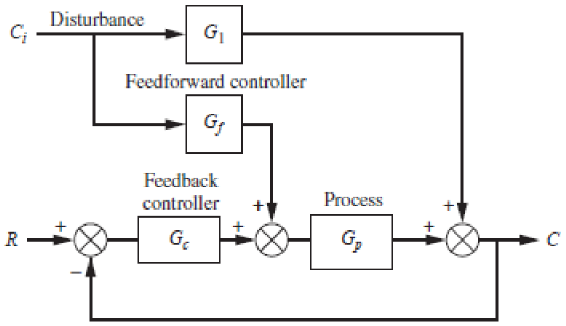


Figure 6: Schematic diagram of control system

(b) **Figure 6** shows a schematic diagram of simple control system application. Answer all question based on **Figure 6**.

i. Describe the type of this control system.

(2 marks)

ii. Discuss **one (1)** advantage and application for this type of control system.

(2 marks)

iii. Compare the function of this controller to a conventional closed loop PID control.

(2 marks)

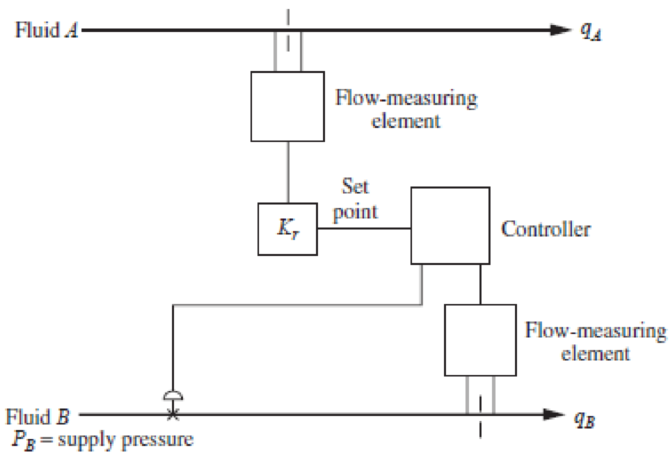


Figure 7: Schematic diagram of control system

(c) **Figure 7** show advanced control system. Answer all question based on **Figure 7**.

i. Describe the type of this control system.

(2 marks)

ii. Discuss **one (1)** advantage and application for this type of control system.

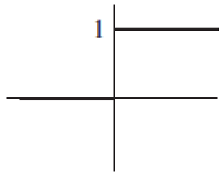
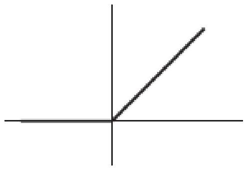
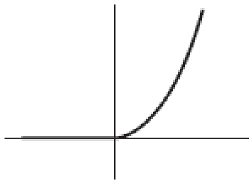
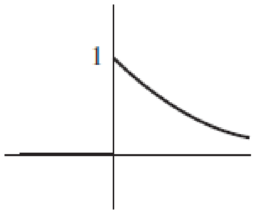
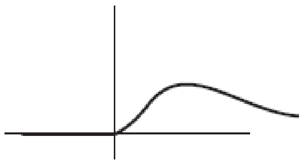
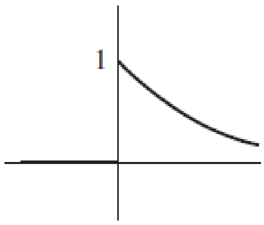
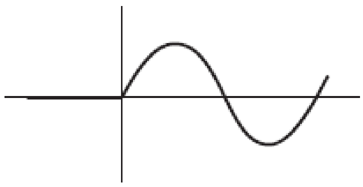
(2 marks)

iii. Compare the function of this controller to a conventional closed loop PID control.

(2 marks)

END OF QUESTION

Appendix

Function	Graph	Transform
$u(t)$		$\frac{1}{s}$
$tu(t)$		$\frac{1}{s^2}$
$t^n u(t)$		$\frac{n!}{s^{n+1}}$
$e^{-at}u(t)$		$\frac{1}{s+a}$
$t^n e^{-at}u(t)$		$\frac{n!}{(s+a)^{n+1}}$
$e^{-at}u(t)$		$\frac{1}{s+a}$
$t^n e^{-at}u(t)$		$\frac{n!}{(s+a)^{n+1}}$
$\sin kt\, u(t)$		$\frac{k}{s^2+k^2}$

4. If you have repeated quadratics,

$$\frac{F(s)}{\cdots \underbrace{(as^2 + bs + c)^n}_{\text{yields}\rightarrow} \cdots} =$$

$$\underbrace{\frac{A_1 s + B_1}{as^2 + bs + c} + \frac{A_2 s + B_2}{(as^2 + bs + c)^2} + \cdots + \frac{A_n s + B_n}{(as^2 + bs + c)^n}}_{n \text{ terms in expansion}} + \cdots$$

Any proper fraction may be resolved into a number of partial fractions subject to the following rules.

1. Factors such as $(as + b)$ in the denominator $F(s)/\cdots(as + b)\cdots$ will produce a term of type $A/(as + b)$, where A is a nonzero constant, in the expansion.
2. If there are repeated factors in the denominator, such as $F(s)/(as + b)^n$, they will produce n terms in the partial fraction expansion.

$$\frac{F(s)}{\underbrace{(as + b)^n}_{\text{root repeated } n \text{ times}}} = \underbrace{\frac{A_1}{as + b} + \frac{A_2}{(as + b)^2} + \cdots + \frac{A_n}{(as + b)^n}}_{\text{there are } n \text{ partial fractions in expansion}}$$

3. Quadratic or polynomial factors that you do not choose to factor yield

$$\frac{F(s)}{\cdots(as^2 + bs + c)\cdots} = \frac{As + B}{\underbrace{as^2 + bs + c}_{\substack{\text{numerator is polynomial of one} \\ \text{less degree than denominator}}}} + \cdots$$