Document No : UniKL MFI_SD_AC41
Revision No: 02
Effective Date: 01 December 2008

**CONFIDENTIAL**

**SET A**

# UNIVERSITI KUALA LUMPUR
## Malaysia France Institute

# FINAL EXAMINATION
## SEPTEMBER 2013 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 6 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**

(a) Compare between batch and continuous process control.

(4 marks)

(b) State **four (4)** process control objectives.

(4 marks)

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

(4 marks)

(d) Sketch the overall response of first order process plant with transport delay.

(4 marks)

(e) Develop transfer function to relate volumetric flow-rate output Q2(s) to Q(s) for non-interacting second order process plant (Refer **Figure 1**).

(10 marks)

(f) Sketch dual tank system to represent interacting second order process plant. Explain the difference of interacting and non-interacting dual tank system process plant.

(4 marks)

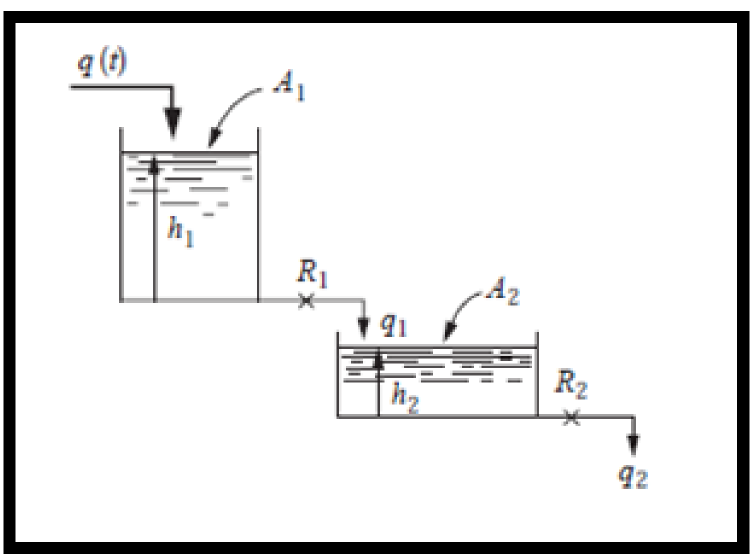



**Figure 1**: Non-interacting process plant

**Question 2**

(a) Summarize the procedure for determining the transfer function for a process.

(2 marks)

(b) Explain concept of steady state and transient state by giving example of liquid level height in a tank of process control system.

(2 marks)

(c) Explain deviation variable and its value in steady state and transient state.

(2 marks)

(d) Explain conservation of mass and its role to model process plant.

(2 marks)

(e) Discuss energy balance and its role in solving temperature related process control system.

(2 marks)

**SECTION B (Total: 60 marks)**

**INSTRUCTION: Answer TWO (2) questions only.**

**Please answers all in answer booklet provided.**

**Question 3**

Answer all questions below based on **Figure 2** and **Table 1.**

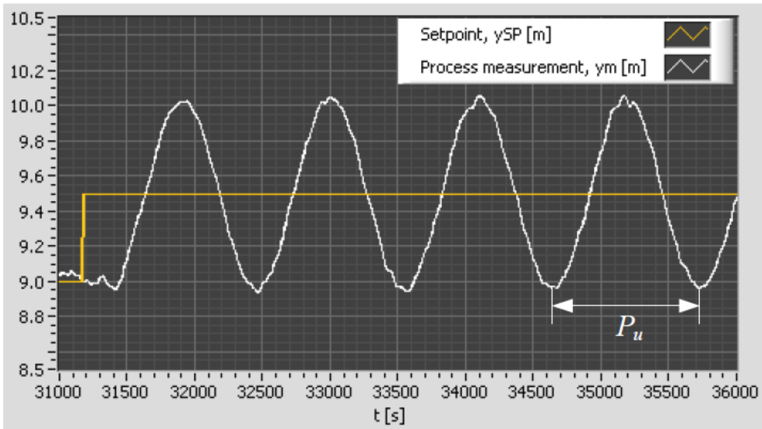



**Figure 2**: Temperature response chart

**Table 1**: Temperature response table

| | $K_p$ | $T_i$ | $T_d$ |
|---|---|---|---|
| P controller | $0.5K_{pu}$ | $\infty$ | 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 difference 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.

(4 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.

(4 marks)

(f) If the proportional band is 50%, calculate the proper optimum value for P, PI and PID controller based on **Figure 2** and **Table 1.**

(8 marks)

**Question 4**

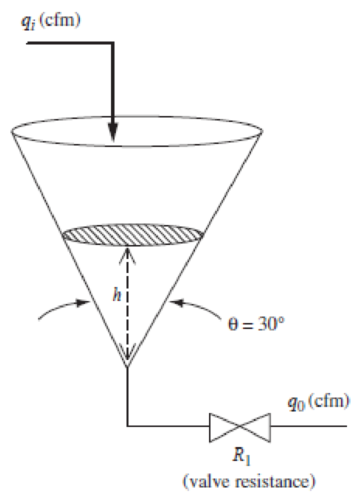



**Figure 3:** Liquid Level System

Consider the system shown in **Figure 3**, which consists of a tank of conical tank to which is attached a flow resistance *R =1* such as a valve, a pipe, or a weir. Assume that *qo*, the volumetric flow rate output (volume/time) through the resistance R, is related to the head *h* by the linear relationship of *qo=h/R*. Answer all questions below.

(a) Develop transfer function to relate output Q o(s) to input Q(s).

(10 marks)

(b) Plot the output response qo(t) under the influence of step input q(t)=10L/min

(5marks)

(c) Develop transfer Function to relate liquid height H(s) under the influence of input Q(s)

(10 marks)

(d) Plot the output response h(t) under the influence of step input q(t)=10L/min.

(5 marks)

**Question 5**

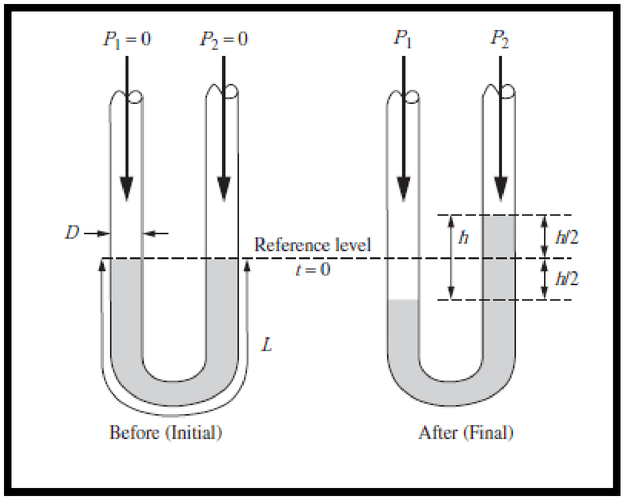



**Figure 4**: Schematic diagram of control system

(a) Answer all question based on **Figure 4**.

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

(3 marks)

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

(15 marks)

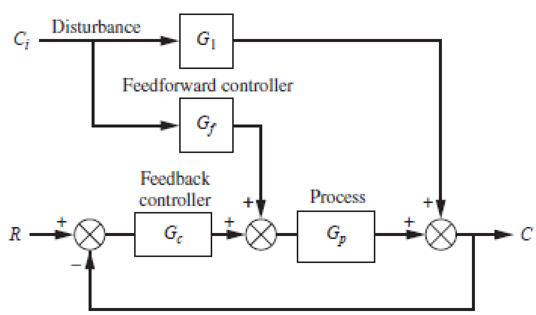



**Figure 5**: Schematic diagram of control system

(b) Answer all question based on **Figure 5**.

i. Describe the type of control system.

(2 marks)

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

(2 marks)

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

(2 marks)

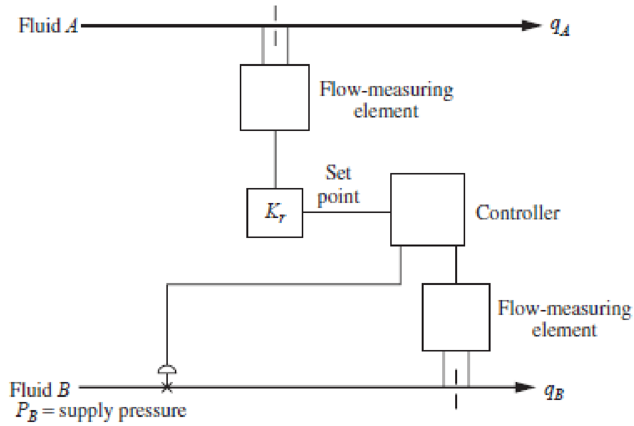



**Figure 6**: Schematic diagram of control system

(c) Answer all question based on **Figure 6**.

i. Describe the type of control.

(2 marks)

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

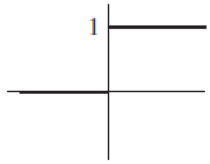
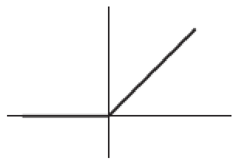
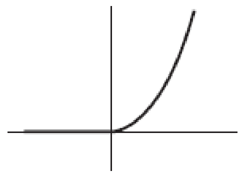
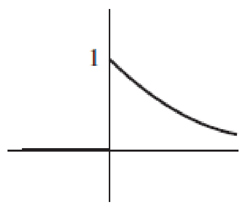
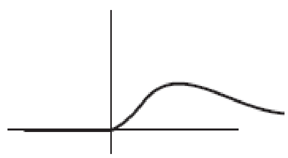
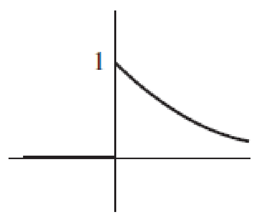
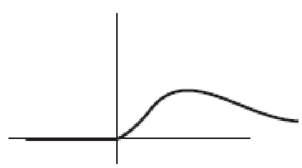
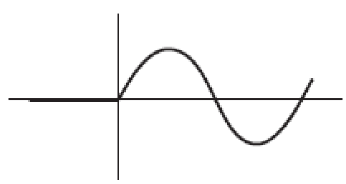
(2 marks)

iii. Compare the function this controller to 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,

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

$$\underbrace{\frac{A_1s+B_1}{as^2+bs+c}+\frac{A_2s+B_2}{(as^2+bs+c)^2}+\cdots+\frac{A_ns+B_n}{(as^2+bs+c)^n}}_{n\text{ terms in expansion}}+\cdots$$

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.

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

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

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