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UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2022/2023

COURSE NAME	:	PROCESS CONTROL SYSTEMS
COURSE CODE	:	BEJ 44603
PROGRAMME CODE	:	BEJ
EXAMINATION DATE	:	JULY/ AUGUST 2023
DURATION	:	3 HOURS
INSTRUCTIONS	:	1. ANSWER ALL QUESTIONS 2.THIS FINAL EXAMINATION IS CONDUCTED VIA **CLOSED BOOK.** 3.STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUCTED VIA CLOSED BOOK

THIS QUESTION PAPER CONSISTS OF **EIGHT (8)** PAGES

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Q1 (a) Describe the defination of process conrol

(2 marks)

(b) List at least **FOUR (4)** process control systems terminology.

(4 marks)

(c) From your point of view, discuss why less variability response are needed in a process control industry.

(2 marks)

(d) Based on Instrument in Piping and Instrumentation Diagram (P&ID), describe the difference between between Locally Mounted Instrument and Board Mounted.

(2 marks)

(e) TangkiPenuh Sdn. Bhd. used cascade controller structure for controlling water level of closed loop tank. The Piping and Instrumentation Diagram (P&ID) of the system is as shown in **Figure Q1(e)**.

(i) Established block diagram of the system.

(10 marks)

(ii) Based on block diagram developed in **Q1(e)(i),** discuss the operation of the system.

(5 marks)

Q2 (a) Describes the importancies of sensor and transducer in process control.

(2 marks)

(b) Discuss how orifice plate can be used for flow measurement.

(5 marks)

(c) The MajuMaju Sdn. Bhd. plan to use orifice plate to measure mass flowrate of water inside the pipe as shown in **Figure Q2(c)**. The specifications given by MajuMaju Sdn. Bhd. are as follows:

Upstream fluid velocity = 200 cm/s
Pressure different between upstream and downstream (P_1-P_2) = 80 Pa
fluid density, ρ =1.6 kg/m^3
volumetric flowrate Q_v= 0.7 m^3/s

As an engineer in the company;

(i) Determine the size of pipe diameter, D and the orifice diameter, d that should be chosen to fulfil the given specification.

(9 marks)

(ii) Calculate mass flowrate Q_m.

(1 mark)

(d) The system used by OhhSedapAir Sdn. Bhd. for maintained closed tank liquid level is illustrated in **Figure Q2(d).** Given that the **H1**=100 cm and Weight Density of the liquid, S = 900 N/m^3.

(i) Calculate **H2** when electrical signal produce by Differential Pressure (DP) is at 11 mA.

(6 marks)

(ii) Based on **Q2(d)(i)**, calculate **H2** when electrical signal produce by Differential Pressure (DP) is at 4 mA, 8 mA, 12 mA and 20 mA.

(2 marks)

Q3 (a) List at least **TWO (2)** controller structure use in process control.

(2 marks)

(b) TeraJu Sdn. Bhd. plan to use Feedforwards controller on its water level system. Given that:

Water level system transfer function, $G_p(s) = \dfrac{3e^{-30s}(s+3)}{(s+6)(s+9)}$

Disturbances transfer function, $G_d(s) = \dfrac{e^{-30s}}{(s+6)(s+9)}$

As an engineer in the company.

(i) Calculate the Feedforward gain, $G_{ff}(s)$ for the system.

(3 marks)

(ii) If the system has Feedforward sensor Gain, ($G_{ffs}(s)$) = 1, Feedback Sensor Gain, ($G_{fbs}(s)$) = 1, Valve Gain, ($G_v(s)$ $G_V(s)$) = 2 and Controller Gain, ($G_c(s)$) $=0.4\left(0.5+\dfrac{1}{100s}\right)$, established the Feedforward block diagram for the system.

(9 marks)

(c) The single tank liquid level is shown in **Figure Q3(c).** The pump of inlet liquid is controlled by on-off controller. When the pump is on, the liquid level inside the tank is rises at 0.05 meter per minute. When the pump is off the water level inside the tank is drop at 0.03 meter per minute. The Set Point (SP) of the tank is at 10 meter and the neutral zone is ±0.3 meter of the Set Point. There is a 5 min lag at the *on* and *off* switch points. Estimate the period of oscillation of the response.

(i) Construct the response of on-off controller for the system.

(7 marks)

(ii) Find the period of oscillation for the system.

(4 marks)

Q4 (a) The plot of input and output open loop experimental data for heat exchanger system is shown in **Figure Q4(a)**.

(i) From **Figure Q4(a)**, established First Order Plus Dead Time (FOPDT) model for the system.

(11 marks)

(ii) Based on Cohen Coon formula, calculate Proportional Integral Derivative (PID) parameter for the system.

(4 marks)

(b) MajuKimia Sdn. Bhd. has proposed **TWO (2)** sets of tuning parameter of Proportional Integral Derivative (PID) controller namely Tune A and Tune B to the PantasAsid Holding for controlling temperature of bleaching system. The response for each of PID tuning is as shown in **Figure Q4(b)**.

(i) By using transient analysis of 5% band, calculate the settling time, Ts for each of the responses.

(9 marks)

(ii) Based on your answer in **Q4(b)(i),** investigates which tuning should be selected by PantasAsid Holding for providing settling, Ts time in regulating temperature for bleaching process.

(1 mark)

- END OF QUESTIONS –

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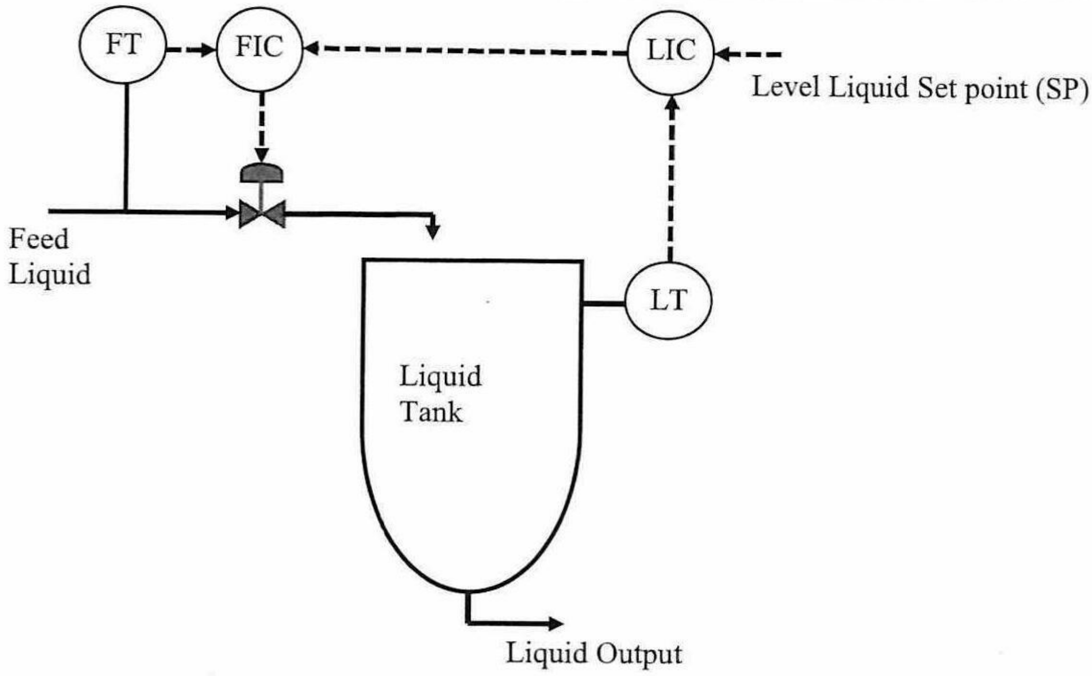

Figure Q1(e)

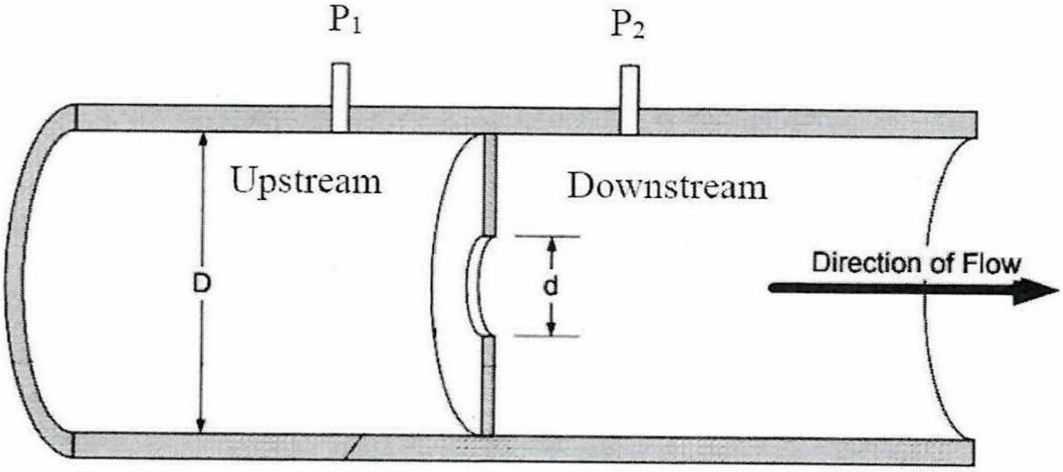

Figure Q2(c)

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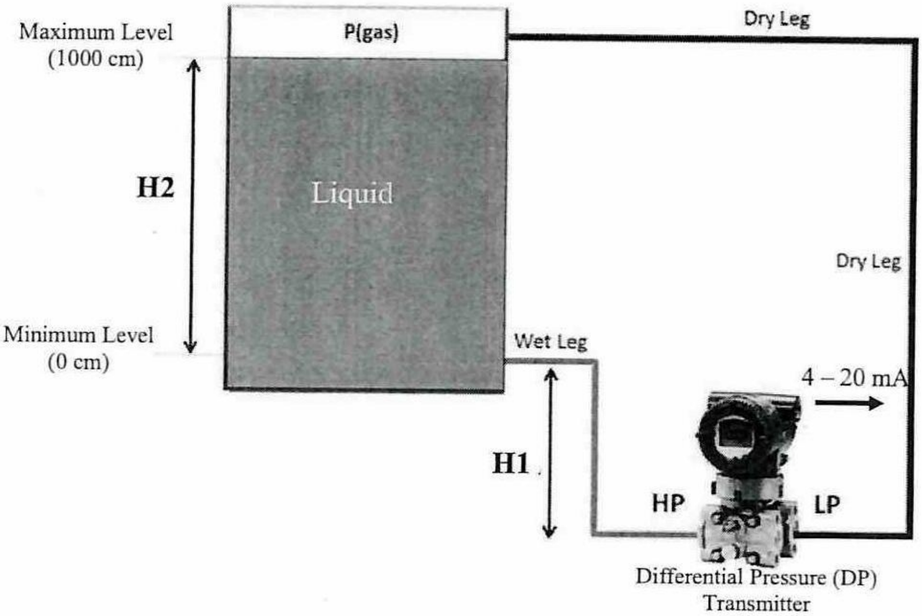

Figure Q2(d)

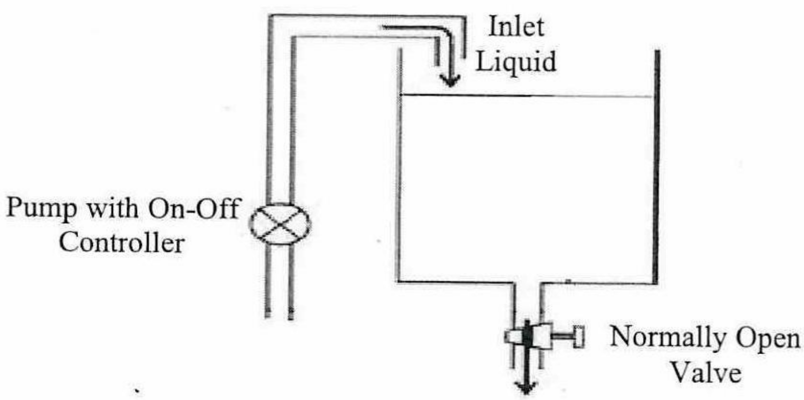

Figure Q3(c)

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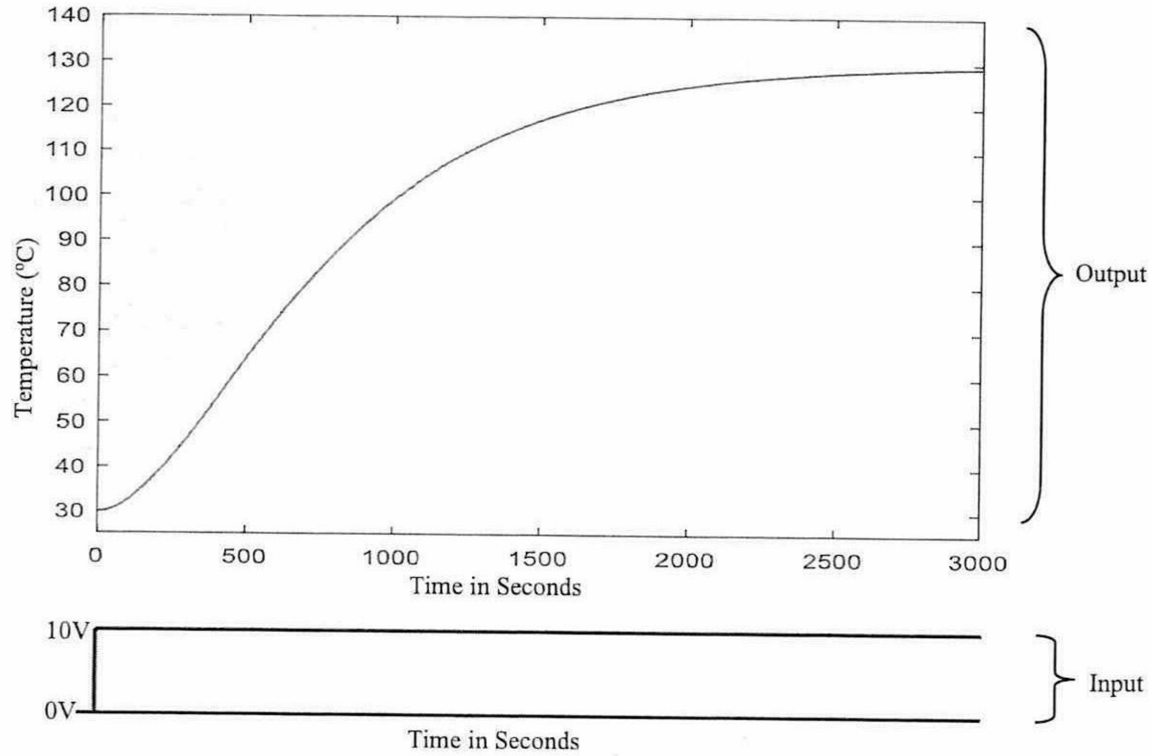

Figure Q4(a)

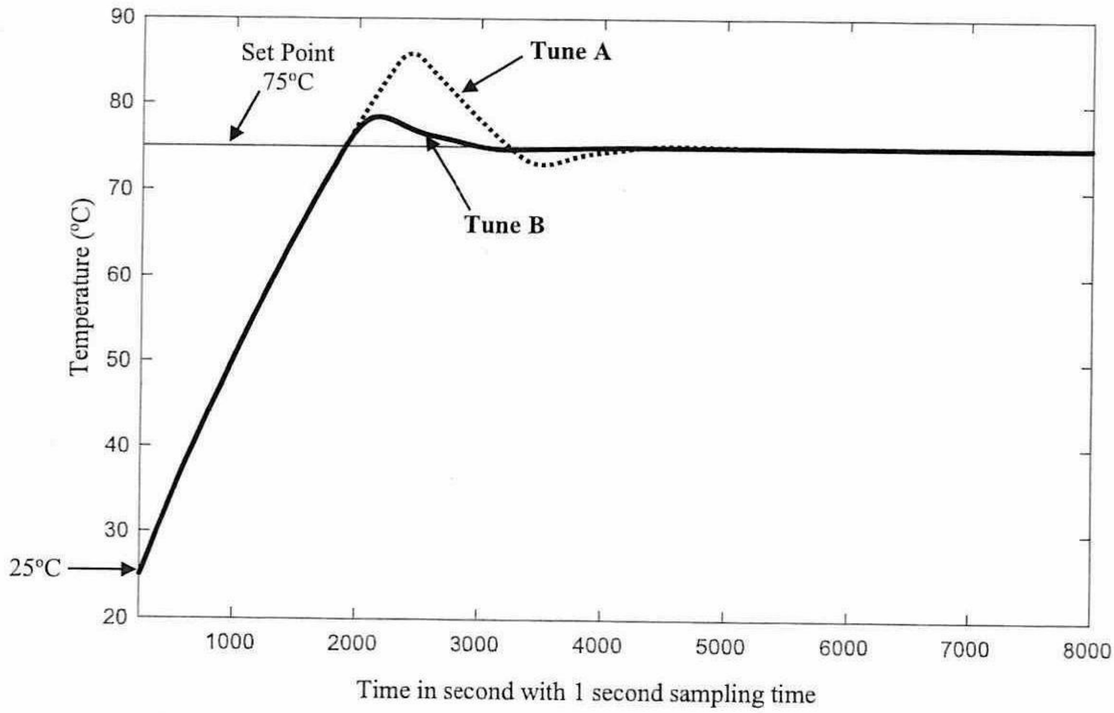

Figure Q4(b)

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FORMULAS

Table A
Cohen Coon Tuning Formulae

Controller	K_p	T_i	T_d
P	$\frac{\tau}{K\theta}\left(1+\frac{\theta}{3\tau}\right)$		
PI	$\frac{\tau}{K\theta}\left(0.9+\frac{\theta}{12\tau}\right)$	$\theta\left(\frac{30+3\left(\frac{\theta}{\tau}\right)}{9+20\left(\frac{\theta}{\tau}\right)}\right)$	
PID	$\frac{\tau}{K\theta}\left(\frac{4}{3}+\frac{\theta}{4\tau}\right)$	$\theta\left(\frac{32+6\left(\frac{\theta}{\tau}\right)}{13+8\left(\frac{\theta}{\tau}\right)}\right)$	$\theta\left(\frac{4}{11+2\left(\frac{\theta}{\tau}\right)}\right)$

Table B
Process Model Equations

Model Name	Model Equation
FOPDT	$G(s)=\frac{Ke^{-\theta s}}{\tau s+1}$
SOPDT	$G(s)=\frac{Ke^{-\theta s}}{\tau^2 s^2+2\zeta\tau s+1}$

Table C
Steady State Analysis Formulae

MSE	$\frac{1}{n}\sum_{t=1}^{n}e_t^2$
RMSE	$\sqrt{\frac{1}{n}\sum_{t=1}^{n}e_t^2}$
ISE	$\int_0^\infty [e(t)]^2\,dt$
ITAE	$\int_0^\infty t\lvert e(t)\rvert dt$