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UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2022/2023

COURSE NAME	:	PROCESS CONTROL SYSTEMS
COURSE CODE	:	BEJ 44603
PROGRAMME CODE	:	BEJ
EXAMINATION DATE	:	FEBRUARY 2023
DURATION	:	3 HOURS
INSTRUCTION	:	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 **SEVEN (7)** PAGES

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Q1 (a) Describe the importance of process control in industry.

(2 marks)

(b) List at least **TWO (2)** industries related to process control.

(2 marks)

(c) Investigate what will happen to the process control system when :

(i) Process Variable (PV) – Set Point (SP)=0

(2 marks)

(ii) Process Variable (PV) – Set Point (SP)≠0

(2 marks)

(d) The Piping and Instrumentation Diagram (P&ID) of a closed loop water level tank used by Duriansedap Sdn. Bhd. is as shown in **Figure Q1(d)**.

(i) Determine the type of control structure used by Duriansedap Sdn. Bhd for controlling the tank water level.

(2 marks)

(ii) Construct a complete block diagram of the system.

(10 marks)

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

(5 marks)

Q2 (a) List at least **THREE (3)** main types measurement in process control.

(3 marks)

(b) Describe the function of valves manifolds.

(2 marks)

(c) The open tank used by Asidcair Sdn. Bhd. for storing a liquid is as illustrated in **Figure Q2(c).**

(i) Develop a linear equation to represent the relationship of liquid level H1 with pressure measured by Differential Pressure (DP).

(6 marks)

(ii) Develop a linear equation to represent the relationship of liquid level H1 with electrical signals produced by Differential Pressure (DP).

(4 marks)

(iii) Based on answer **Q2(c)(ii),** calculate the liquid level H1 when the electrical signal produced by Differential Pressure (DP) is at 7 mA and at 18 mA.

(4 marks)

(d) Selamat Sdn. Bhd. has been assigned by Waras Holding for selecting the control valves that are capable of handling slurries and capable of minimizing the leakage to the environment.

(i) Select the control valves that fulfill Waras Holding requirement.

(2 marks)

(ii) Defend your selection in **Q2(d)(i).**

(4 marks)

Q3 (a) List at least **TWO (2)** major approaches for modeling.

(2 marks)

(b) The plot of input and output open loop experimental data for the heat exchanger system is shown in **Figure Q3(b)**.

(i) From **Figure Q3(b)** and **Figure Q3(b)(i)**, develop the Second Order Plus Dead Time (SOPDT) model for the system.

(19 marks)

(ii) Calculate PID parameter for the system.

(4 marks)

Q4 (a) ZamChemical Sdn. Bhd. has proposed **TWO (2)** sets of tuning parameters for a Proportional Integral (PI) controller namely Tune A and Tune B to the PowerOil Holding for controlling temperature of the batch oil bleaching process. The response for each PI tuning is as shown in **Figure Q4(a)**.

(i) By using transient analysis of 2% band, estimates the settling time, Ts and overshoot percentages, $\% \mu(s)$ for each of the responses.

(13 marks)

(ii) Based on your answer in **Q4(a)(i),** determine which tuning should be selected by PowerOil Holding for providing proper regulation of temperature for the batch oil bleaching process.

(2 marks)

(b) ManService Sdn. Bhd. has proposed **TWO (2)** sets of tuning parameters of Proportional Integral (PI) controller namely Tune A and Tune B to the OilWangi Holding for controlling temperature of heat exchanger system. ManService Sdn. Bhd has attached a steady state data for both of PI tuning (Tune A and Tune B) in controlling temperature of heat exchanger system to the OilWangi Holding and the data are shown in **Table Q4(b)(i)** and **Table Q4(b)(ii)** respectively. By using Root Mean Square Error (RMSE) analysis, it investigates which tuning should be chosen by OilWangi Holding towards achieving small process variability (small steady state error) while controlling the temperature of the heat exchanger system.

(10 marks)

- END OF QUESTIONS –

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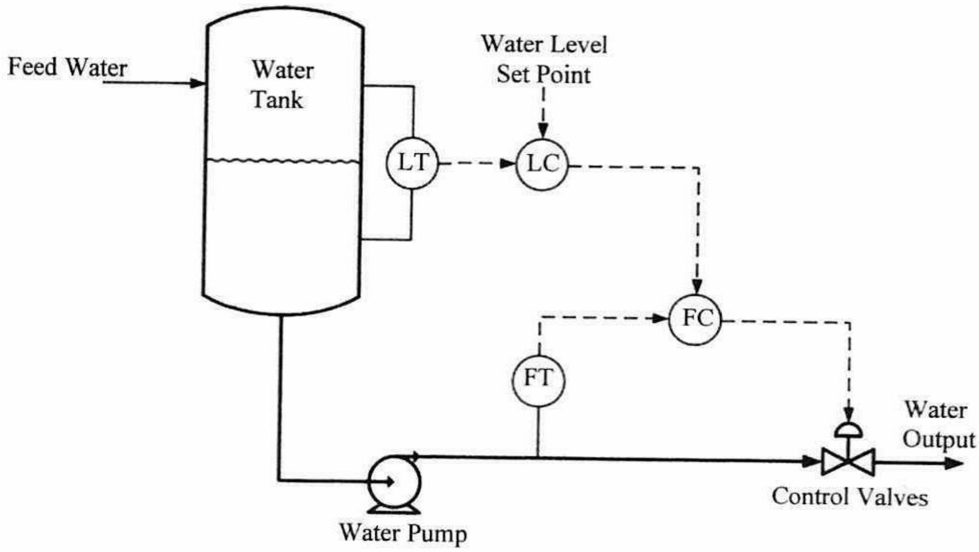

Figure Q1(d)

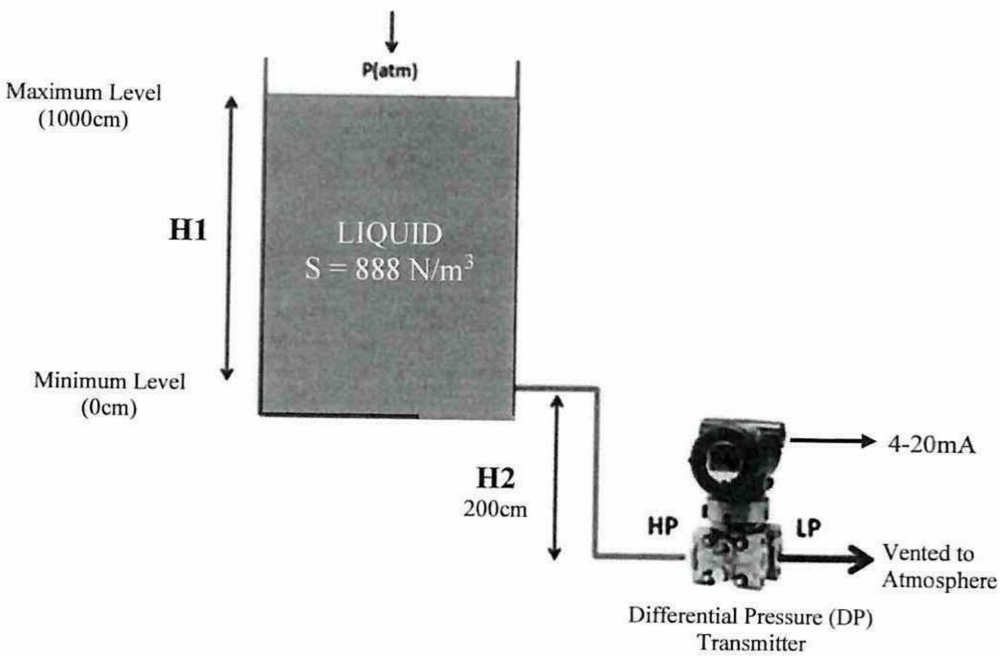

Figure Q2(c)

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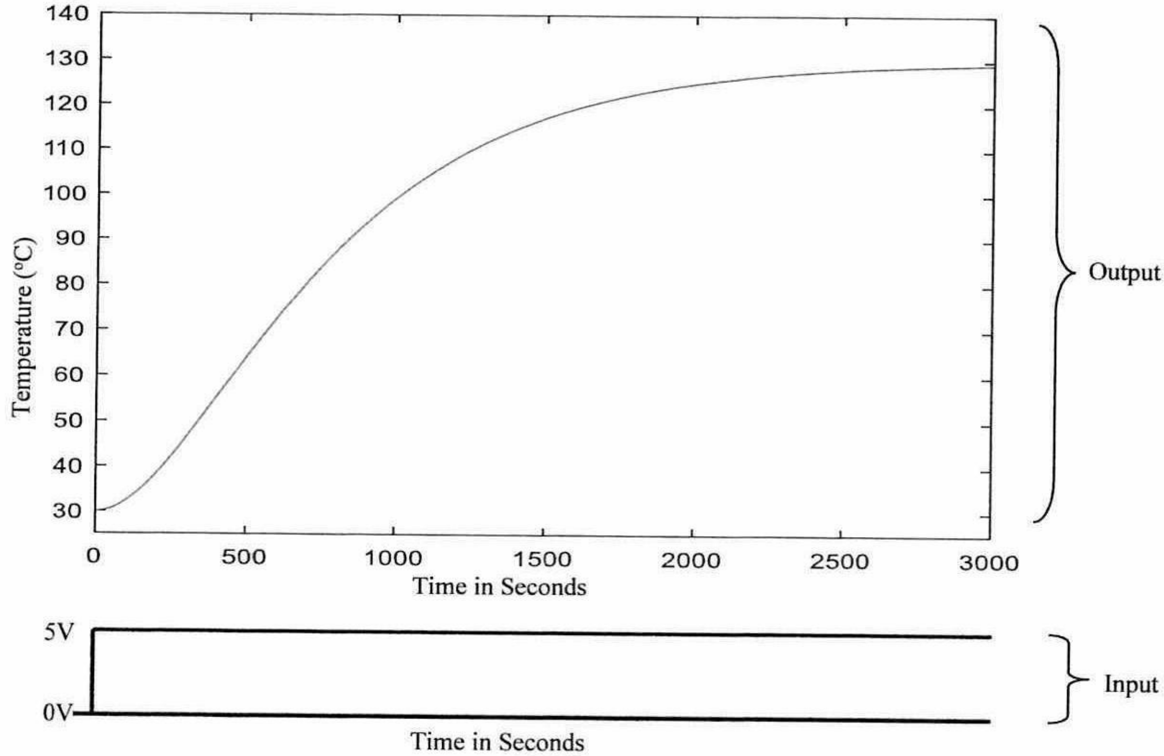

Figure Q3(b)

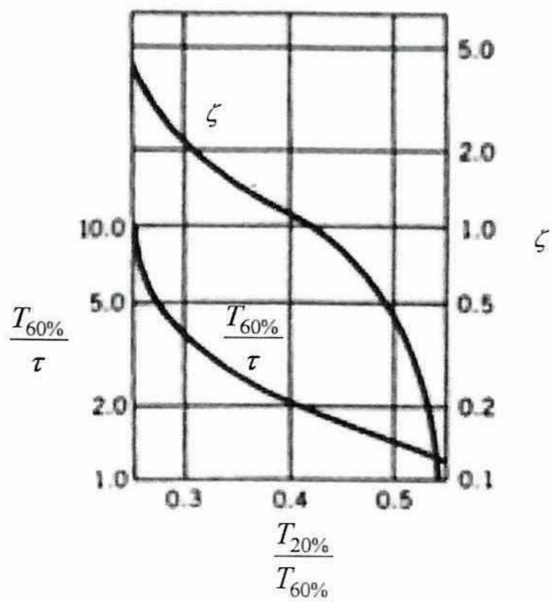

Figure Q3(b)(i)

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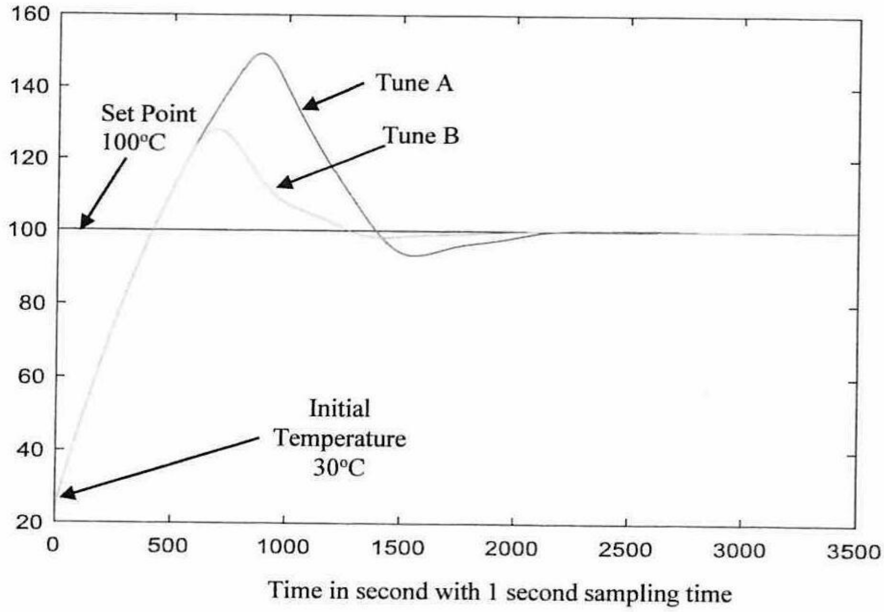

Figure Q4(a)

Table Q4(b)(i)
PI Tune A

No	Set Point (SP) in °C	Process Variable (PV) in °C
1	135	135.163
2	135	134.886
3	135	134.698
4	135	135.162

Table Q4(b)(ii)
PI Tune B

No	Set Point (SP) in °C	Process Variable (PV) in °C
1	135	135.161
2	135	134.273
3	135	136.689
4	135	134.202

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FORMULAS

Table A
Ziegler Nichols Tuning Formulae

Controller	K_p	T_i	T_d
P	$\frac{\tau}{K\theta}$		
PI	$\frac{0.9\tau}{K\theta}$	$\frac{\theta}{0.3}$	
PID	$\frac{1.2\tau}{K\theta}$	2θ	0.5θ

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	$\int_0^{\infty} t\lvert e(t)\rvert dt$