UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
(ONLINE)
SEMESTER II
SESSION 2020/2021

COURSE NAME	:	PROCESS CONTROL
COURSE CODE	:	BEH42103
PROGRAMME CODE	:	BEJ
EXAMINATION DATE	:	JULY 2021
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS. **OPEN BOOK EXAMINATION**

THIS QUESTION PAPER CONSISTS OF EIGHT (8) PAGES

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

(2 marks)

(b) List two (2) types of industry that apply process control in their operation.

(2 marks)

(c) Discuss why high variability response is consider as poor control.

(3 marks)

(d) Heat Exchanger system used by HafizSedapRestaurant during producing hot milk is as shown in **Figure Q1(d).** Based on **Figure Q1(d)**:

(i) Point out the type of control structure used by the system.

(2 marks)

(ii) Construct the block diagram of the system.

(11 marks)

(e) Discuss the function of Piping and Instrument Diagram (P&ID) in process control.

(2 marks)

(f) Analyze the total Locally Mounted Instrument and Board Mounted Instrument for a system shown in **Figure Q1(d)**.

(3 marks)

Q2 (a) The system that used by AirManis Sdn. Bhd. for maintaining Liquid level in an open tank is illustrated in **Figure Q2(a)**. The liquid has a density, $\rho = 86.65$ kg/m^3 and the gravitational acceleration, $g = 9.81$ m/s^2. Given that the pressure measured by Differential Pressure (DP) at maximum level (URV) is equal to 10200 Pascal (Pa) and the Differential Pressure (DP) at maximum level (LRV) is equal to 1700Pascal (Pa).

(i) Calculate the heights of H1 and H2.

(4 marks)

(ii) Estimate the electrical current produced by DP when the the pressure measured by DP is equal to 8000Pa.

(6 marks)

(iii)Estimate the height of H1 when electrical signal produced by DP is equal to 9 mA.

(6 marks)

(b) The GaharuOil Sdn. Bhd plans to use orifice plate to measure volumetric flowrate of oil inside the pipe as shown in **Figure Q2(b)**. The specification that given by GaharuOil Sdn. Bhd is as follows:

Upstream fluid velocity, V_1 = 250 cm/s
Fluid density, ρ =1.8 kg/m^3
Pressure different between upstream and downstream (P_1-P_2) = 45 Pa
Discharge Coefficient = 0.62
Mass flow rate, Q_m =0.256 kg/s

As an engineer in the company, estimate the size of the orifice diameter, d and the pipe diameter, D.

(9 marks)

Q3 (a) Ahmad has been assigned by his client to choose a valve that is able to handle slurries and abrasive flow.

(i) Select the type of valve that should be chosen by Ahmad to fulfill his client requirement.

(2 marks)

(ii) Point out the reason of answer in **Q3(a)(i).**

(2 marks)

(b) OliChemical Sdn. Bhd uses a ratio control scheme to maintain a ratio Liquid A and Liquid B for maintaining the quality of chemical products that produced by the company. In designing the ratio control for the system, the liquid A stream is set as *disturbance stream* whereas Liquid B stream is set as *manipulated stream*. The other information related to the system are given as follows:

The span of the flow transmitters for liquid B is 0.25 L/min.
The Ratio Station gain K_R is 0.022.

(i) Describe the definition of *disturbance stream* and *manipulated stream* in ratio control system

(2 marks)

(ii) If the ratio of the molar flow rates, R_d is equal to 0.0018, calculate the spans of the flow transmitter for liquid A.

(2 marks)

(iii)Based on ratio of the molar flow rates, R_d in **Q3(b)(ii)**, Calculate the Ratio Station gain K_R if liquid A is set as *manipulated stream* while liquid B is set as *disturbance stream.*

(2 marks)

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(c) Based on plot of input and output open loop experimental data for crude oil bleaching process as shown in **Figure Q3(c)**, estimate the First Order Plus Dead Time (FOPDT) model for the system.

(15 marks)

Q4 (a) The First Order Plus dead Time (FOPDT) model for fragrant lemongrass steam distillation system is as shown below:

$$\text{FOPDT} = \frac{4000e^{-300s}}{1200s+1}$$

(i) Based on Ziegler-Nichols (ZN) tuning formula, calculate the parameter of robust PID (PID with Back Calculation Anti-Windup) for the system.

(4 marks)

(ii) Establish the robust PID block diagram for the system.

(4 marks)

(b) Rahman Sdn. Bhd. has proposed **TWO (2)** sets of tuning for a Proportional Integral Derivative (PID) controller namely Tune A and Tune B to the Zahrul Holding for controlling temperature of continuous Jacket Reactor in oil and gas industries handled by the company. The response for both PID tuning (Tune A and Tune B) in controlling temperature of continuous Jacket Reactor is as shown in **Figure Q4(b)**. Meanwhile the samples of steady state data for both of PID Tune A and Tune B are shown in **Table Q4(b)(i)** and **Table Q4(b)(ii)** respectively.

(i) By using transient analysis of 2% band and Mean Square Error (MSE), estimates the settling time, overshoot and steady state error for each of the responses.

(14 marks)

(ii) Zahrul Holding has been set specification for temperature regulation of continuous Jacket Reactor as follow:

Settling time, Ts < 1600 second
% Overshoot < 5%
Mean Square Error at steady state < 0.009

Based on answer Q4b(i), examine the tuning that should be select by Zahrul Holding and reason of the selection.

(3 marks)

- END OF QUESTIONS -

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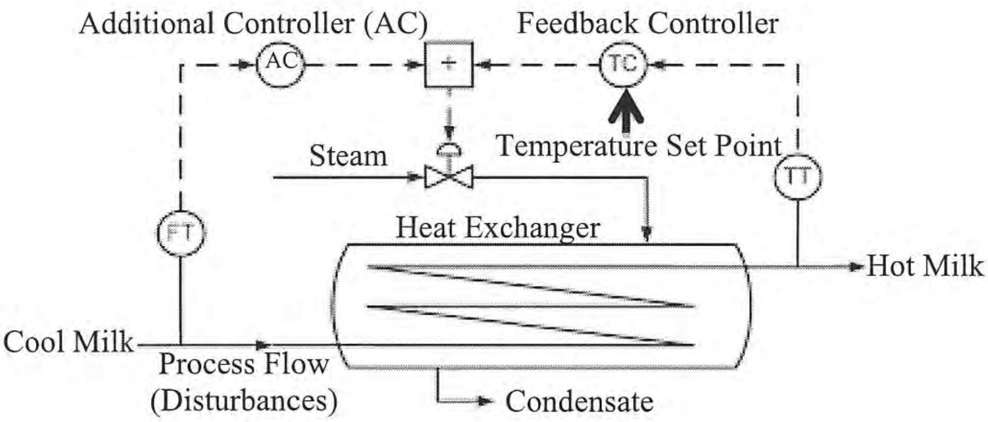

Figure Q1(d)

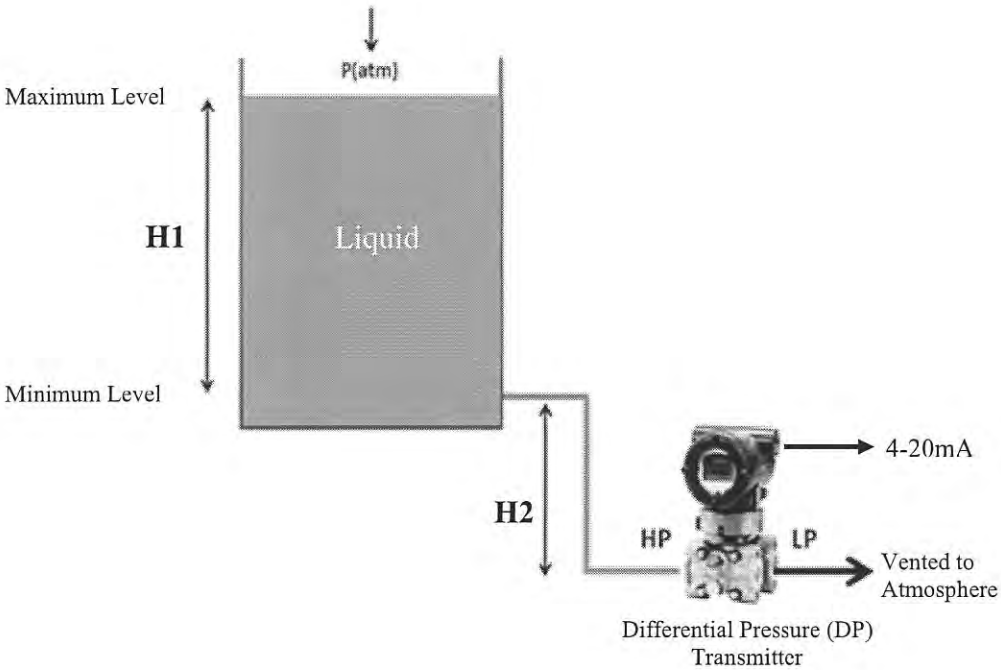

Figure Q2(a)

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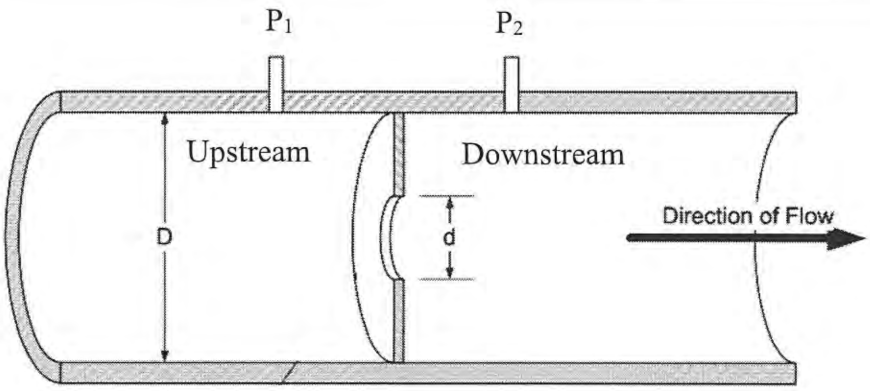

Figure Q2(b)

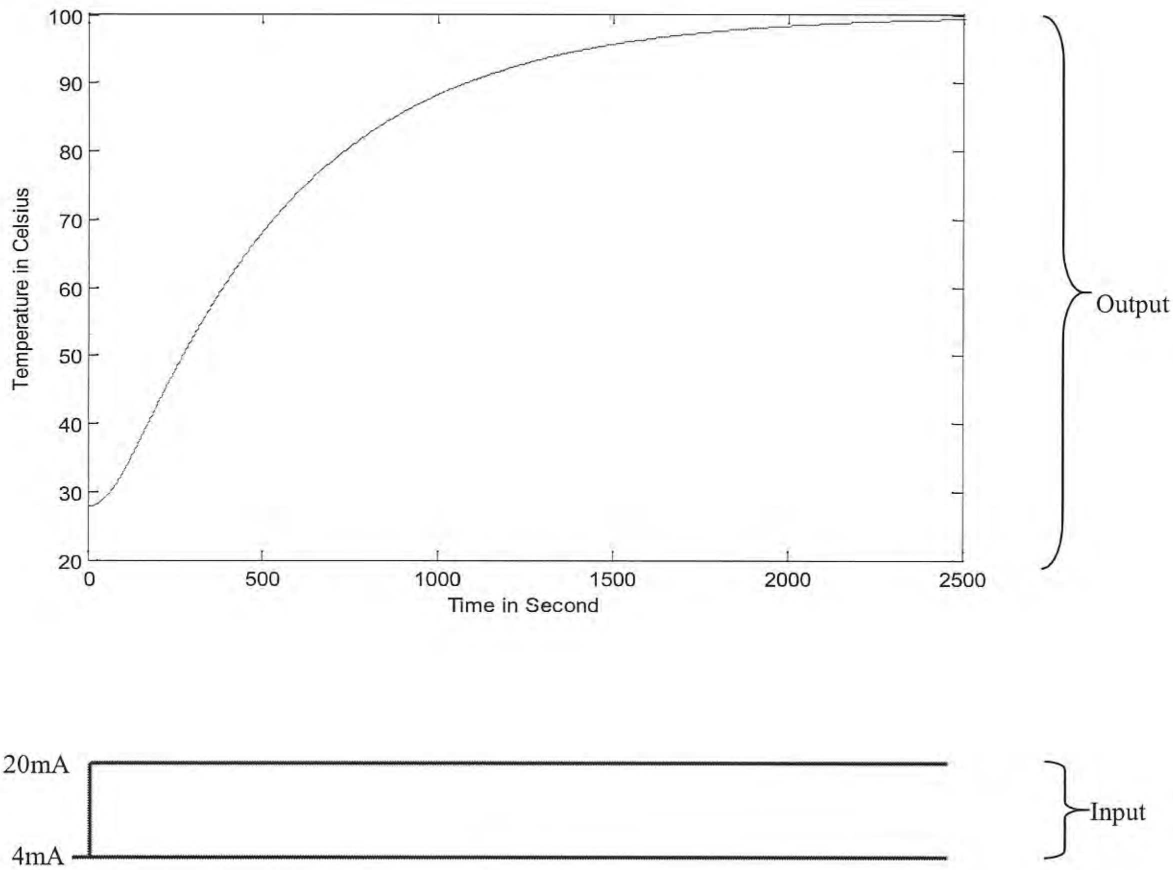

Figure Q3(c)

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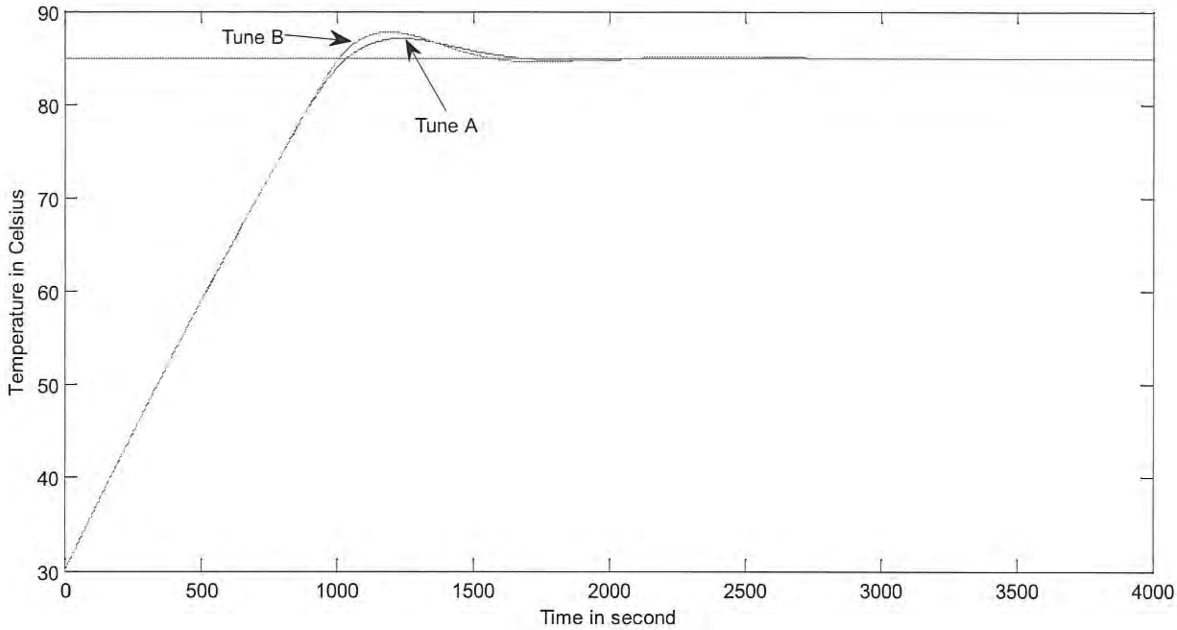

Figure Q4(b)

Table Q4(b)(i)
PID Tune A

No	Set Point (SP) in °C	Process Variable (PV) in °C
1	85	84.9112
2	85	84.9119
3	85	84.9127
4	85	84.9134
5	85	84.9141

Table Q4(b)(ii)
PID Tune B

No	Set Point (SP) in °C	Process Variable (PV) in °C
1	85	85.0177
2	85	85.0184
3	85	85.0191
4	85	85.0197
5	85	85.0204

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FORMULAE

Table A
Ziegler-Nichols Tuning Formulae

Controller	K_p	T_i	T_d
P	$\frac{\tau}{K\theta}$		
PI	$0.9\frac{\tau}{K\theta}$	$\frac{\theta}{0.3}$	
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	$\int_0^\infty t\lvert e(t)\rvert dt$

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