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UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
(TAKE HOME)
SEMESTER II
SESSION 2019/2020

COURSE NAME	:	PROCESS CONTROL SYSTEMS
COURSE CODE	:	BEH42103
PROGRAMME CODE	:	BEJ
EXAMINATION DATE	:	JULY 2020
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS. **OPEN BOOK EXAMINATION**

TERBUKA

THIS QUESTION PAPER CONSISTS OF NINE (9) PAGES

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Q1 (a) Describe the definition of components of process control listed below:

(i) Sensor

(2 marks)

(ii) Final Control Element (FCE)

(2 marks)

(b) Based on process variable (PV) variability concept, differentiate between poor control and good control.

(6 marks)

(c) Distinguish between Locally Mounted Instrument and Board Mounted Instrument in Piping and Instrumentation Diagram (P & ID).

(6 marks)

(d) Water heating system used by Manisah Restaurant during producing hot milk is as shown in **Figure Q1(c)**. Based on **Figure Q1(c)**:

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

(2 marks)

(ii) Construct the block diagram of the system.

(7 marks)

Q2 (a) The system used by RinaSedapAir Sdn. Bhd. for maintained open tank water level is illustrated in **Figure Q2(a).** Given that the H2=500mm. If the pressure measured by Differential Pressure (DP) at maximum level is equal to 14715Pascal (Pa) and the relationship equation between height of water level with pressure measured by DP is described by following equation,

$$y = 0.000101P + C$$

where y refers to the height of water level H1 and P refers to the pressure measured by DP in Pascal (Pa).

(i) Calculate the maximum height of water level H1 of the tank.

(6 marks)

(ii) Estimate the electrical current produced by DP when the the pressure measured by DP is equal to 13000Pa.

(6 marks)

(b) The venturi tube shown in **Figure Q2(b)** is used by Petrol Oil Holding to measure the speed of a oil fluid in a pipe. The cross-sectional areas at point A are 15 cm^2 and the liquid speed at V_1 is 3.11 m/s whereas the fluid density, ρ is equal to 1.56 kg/m^3. Given that the pressure difference measured by the venturi, $\Delta p=(P_1-P_2)$ is equal to 3 Pascal (Pa).

(i) Calculate the fluid speed at V_2.

(4 marks)

(ii) Estimate the mass flow rate, Q_m measured by the venturi tube.

(6 marks)

(c) List at least **ONE (1)** type of valve and describe at least **ONE (1)** advantage and **ONE (1)** disadvantage of the valve.

(3 marks)

Q3 (a) Ahmad has been assigned by his client to design the temperature controller for heat exchanger system. The specific requirement of the temperature controller requested by Ahmad client is as follows:

"the controller must be able to reject disturbance before it disturbs or disrupts the system"

(i) Select the controller structure that should be chosen by Ahmad to fulfill his client requirement.

(1 marks)

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

(2 marks)

(b) The single tank liquid level is shown in **Figure Q3(b).** The pump of inlet liquid is controlled by an On-Off controller. When the pump is On, the liquid level inside the tank rises at 0.1 meter per minute. When the pump is Off the water level inside the tank is drop at 0.05 meter per minute. The Set Point (SP) of the tank is at 2 meter and the neutral zone is ±0.3 meter of the Set Point. There is a 0.5 min lag at the On and Off switch points. Estimate the period of oscillation of the response.

(10 marks)

(c) The plot of input and output open loop experimental data for the heat exchanger system is shown in **Figure Q3(c)**. As an engineer, your are required to design a Proportional Integral Derivative (PID) controller for the system.

(i) Calculate the value of the Proportional Gain (K_p), Integral Gain (K_i) and Derivative Gain (K_d) for PID controller for the system based on Ziegler-Nichols approach.

(8 marks)

(ii) Established the complete block diagram of the overall system.

(4 marks)

Q4 (a) Zamaju Sdn. Bhd. has proposed **THREE (3)** sets of tuning parameter for a Proportional Integral Derivative (PID) controller namely Tune A ,Tune B and Tune C to the Putera Holding for controlling temperature of batch steam distillation for essential oil production handled by the company. The response for each PID tuning (Tune A, Tune B and Tune C) in controlling temperature of batch steam distillation is as shown in **Figure Q4(a)**.

(i) By using transient analysis of 2% band, estimates the settling time and overshoot for each of the responses.

(12 marks)

(ii) Based on your answer in Q4(a)(i), analyze which tuning should be rejected by Putera Holding for preventing improper regulation of temperature of batch steam distillation system.

(2 marks)

(b) Rahman Sdn. Bhd. has proposed **TWO (2)** sets of tuning parameter for a Proportional Integral Dericative (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. Haziq M. H. Sdn. Bhd. has attached a steady state data for both of PID tuning (Tune A and Tune B) in controlling temperature of continuous Jacket Reactor and the data are shown in **Table Q4(b)(i)** and **Table Q4(b)(ii)** respectively. By using Root Mean Square Error (RMSE) analysis, investigate which tuning should be choosen by Zahrul Holding towards achieving small process variability (small steady state error) while controlling the temperature of continuous Jacket Reactor.

(11 marks)

- END OF QUESTIONS –

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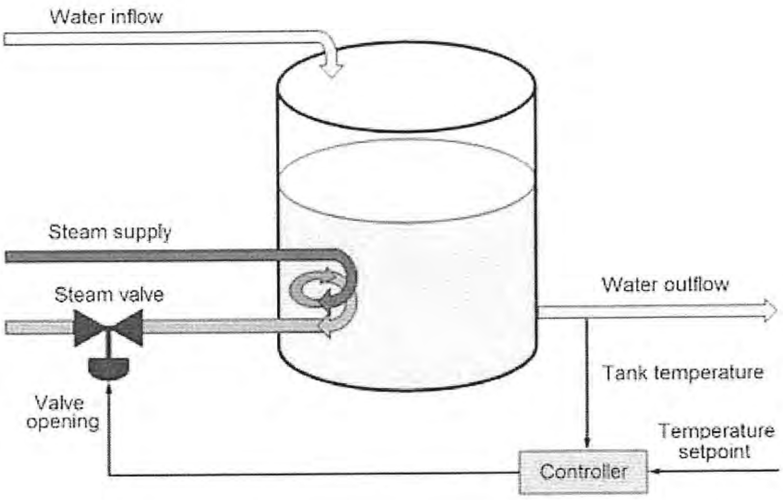

Figure Q1(c)

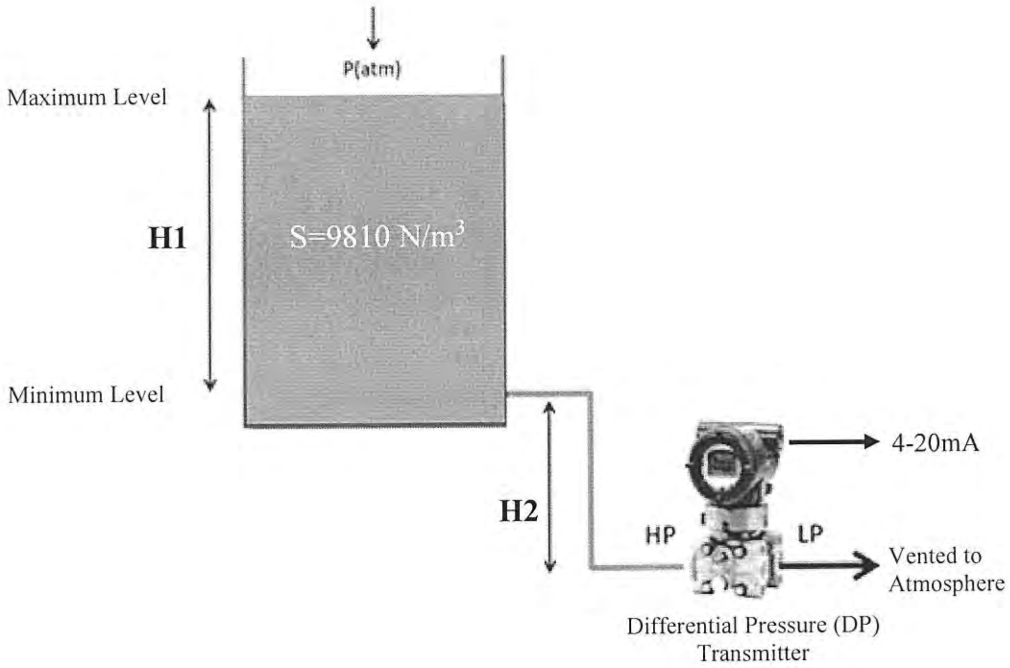

Figure Q2(a)

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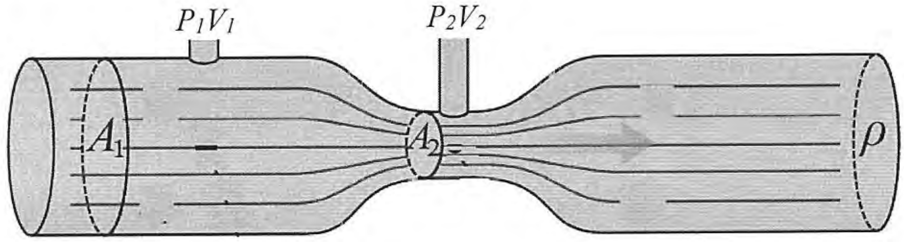

Figure Q2(b)

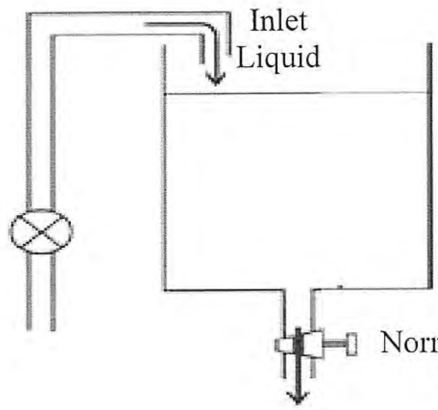

Figure Q3(b)

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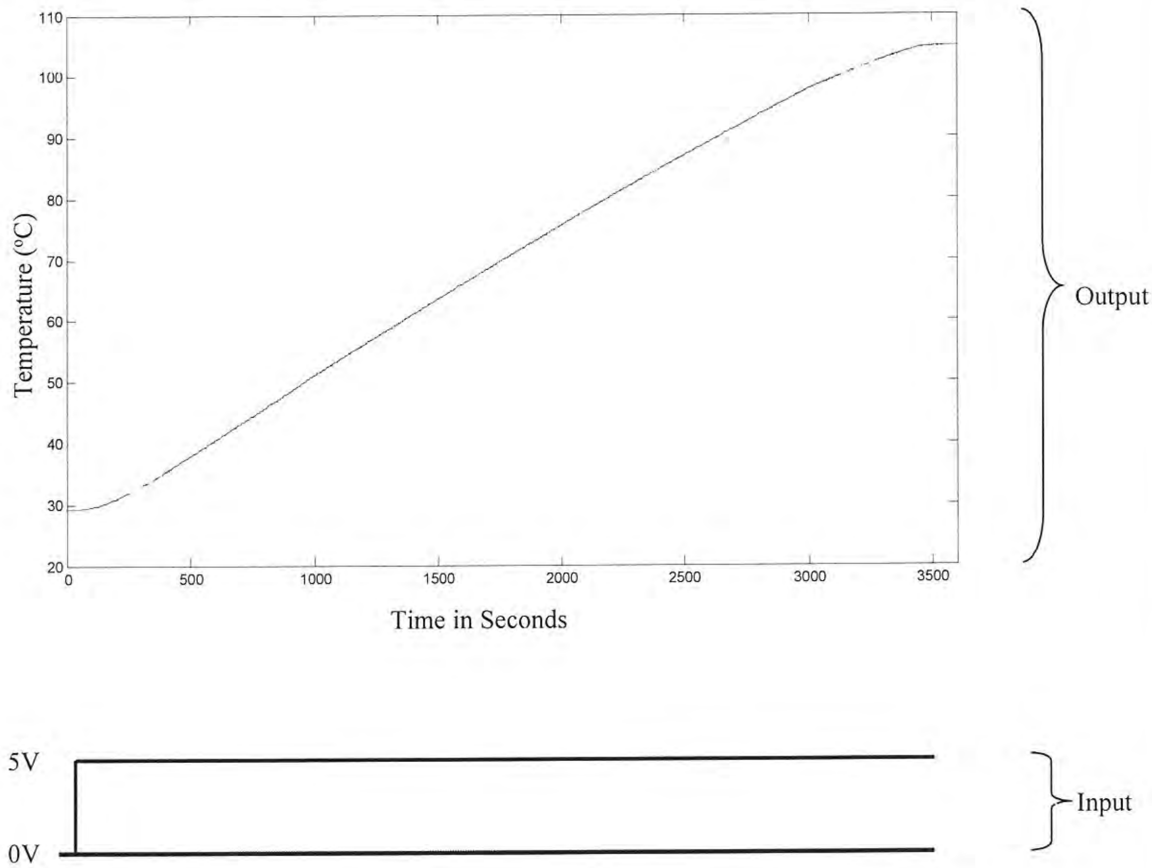

Figure Q3(c)

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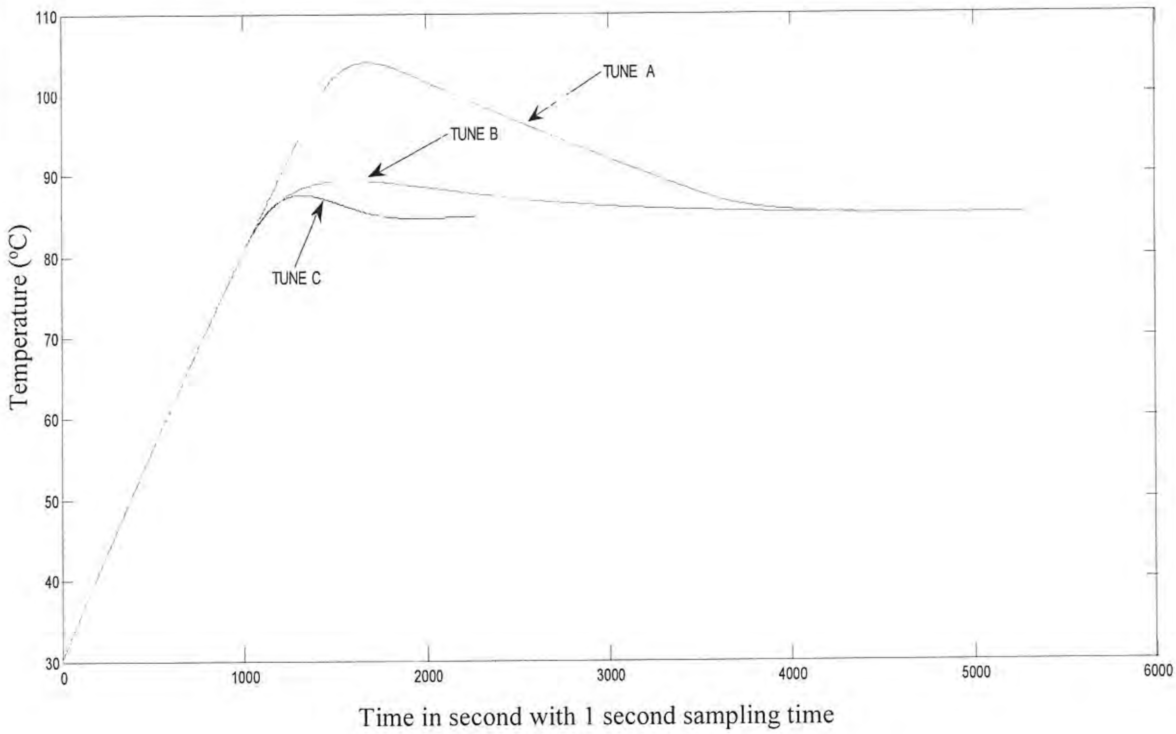

Figure Q4(a)

Table Q4(b)(i)
PID Tune A

No	Set Point (SP) in °C	Process Variable (PV) in °C
1	90	91.101
2	90	89.486
3	90	89.678
4	90	90.432
5	90	89.210

Table Q4(b)(ii)
PID Tune B

No	Set Point (SP) in °C	Process Variable (PV) in °C
1	90	90.231
2	90	88.973
3	90	91.689
4	90	92.102
5	90	88.792

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FORMULAE

Table A
Cohen Coon Tuning Formulae

Controller	K_p	T_i	T_d
P	$\frac{\tau}{\theta}$		
PI	$0.9\frac{\tau}{\theta}$	$\frac{\theta}{0.3}$	
PID	$1.2\frac{\tau}{\theta}$	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	$\int_0^\infty t\lvert e(t)\rvert dt$