Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2019/2020

COURSE NAME	:	PROCESS CONTROL SYSTEMS
COURSE CODE	:	BEH42103
PROGRAMME CODE	:	BEJ
EXAMINATION DATE	:	DECEMBER 2019 /JANUARY 2020
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS

THIS QUESTION PAPER CONSISTS OF NINE (9) PAGES

Q1 (a) Describe the importance of automatic process control

(2 marks)

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

(4 marks)

(c) Water Heating system used by Mamat Warung Holding during producing hot coffee 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) Illustrate the block diagram of the system.

(8 marks)

(iii) Examine the function of Controller 1 and Controller 2 on the system.

(4 marks)

Q2 (a) List **TWO (2)** process parameter that commonly measured in process control system.

(2 marks)

(b) The system used by Cemara Holding for maintained open tank water level is illustrated in **Figure Q2(b)**. Given that the H1=5000mm and H2=200mm.

(i) Estimate the electrical current produced by Differential Pressure (DP) when the ΔP=40000Pa.

(9 marks)

(ii) Based on **Q2(b)(i)**, calculate the water level when ΔP=40000Pa

(5 marks)

(c) Ahmad has been assigned by his client to design the temperature mesurement system that has capability to measure temperature between 400°C to 700°C. To fulfill this temperature range measurement demand, Ahmad has been select Resistance Temperature Detector (RTD) with Nickel material based. Explain either this selection of Resistance Temperature Detector (RTD) is correct or wrong.

(4 marks)

Q3 (a) Describe the operation and application of Globe Valve.

(5 marks)

(b) Hani M. H. Sdn. Bhd. has difficulties to provide robust temperature regulation on its heat exchanger system using feedback controller. This is due to incapability of feedback controller to cope with the present of disturbances caused by inconsistency flow rate of steam. To solve this problem, Hani M. H. Sdn. Bhd. plan to use Feedforwards controller. Given that:

Heat exchanger transfer function, $G_p(s) = \dfrac{e^{-15s}}{10s+1}$

Disturbance transfer function, $G_d(s) = \dfrac{e^{-30s}}{10s+1}$

(i) Calculate the Feedforward gain for the system.

(4 marks)

(ii) If the system has Feedforward Sensor Gain, $(G_{ffs}(s)) = 1$, Feedback Sensor Gain, $(G_{fbs}(s)) = 1$, Valve Gain, $(G_v(s)) = 1$ and Controller Gain, $(G_c(s)) = 0.7\left(2 + \dfrac{1}{50s}\right)$, construct the Feedforward block diagram for the system.

(11 marks)

Q4 (a) The temperature of heat exchanger system is controlled by an on-off controller. When the heater is *on* the temperature rises at 0.7 celcius per minute. When the heater is *off* the temperature drop at 0.5 celcius per minute. The Set Point (SP) is at 85 celcius and the neutral zone is ±5 celcius of the setpoint. There is a 2 min lag at the *on* and *off* switch points. Estimate the maximum peak of temperature when the heater is at *on* condition.

(4 marks)

(b) Hafiz A. J. Holding in a way for developing Proportional Integral Derivative (PID) controller for herbs dryer system. The plot of input and output open loop experimental data for the herbs dryer system is shown in **Figure Q4(b)**.

(i) Estimate the First Order Plus Dead Time (FOPDT) model for the system

(8 marks)

(ii) Calculate the value of Proportional Gain (K_p), Integral Gain (K_i) and Derivative Gain (K_d) for PID controller for the system based on Cohen Coon approach.

(3 marks)

(iii) Established PID controller block diagram for the system.

(5 marks)

Q5 (a) Haziq M. H. Sdn. Bhd. has proposed **TWO (2)** set tuning parameter of Proportional Integral Derivative (PID) controller namely Tune A and Tune B to the Zaza Slim Holding for controlling temperature of batch steam distillation for essential oil production handled by Zaza Slim Holding. The response for both of PID tuning (Tune A and Tune B) in controlling temperature of batch steam distillation is as shown in **Figure Q5(a)(i)** and **Figure Q5(a)(ii)** respectively. By using transient analysis 2% band, investigates which tuning should be choosen by Zaza Slim Holding towards minimizing batch cycle time.

(15 marks)

(b) The steady state data of temperature response for steam distillation process controlled by Proportional Integral Derivative (PID) controller is as tabulated in **Table Q5(b)**. Calculate Mean Square Error (MSE) of the data.

(5 marks)

- END OF QUESTIONS –

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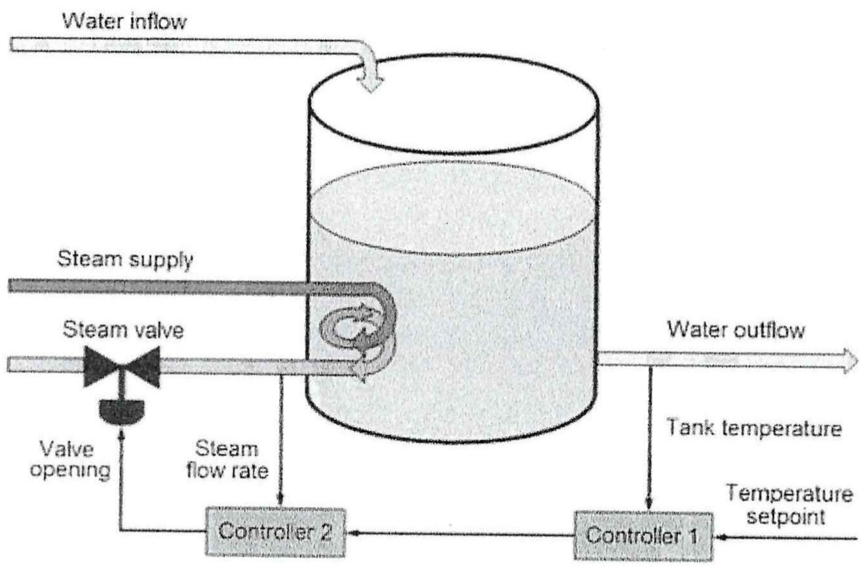

Figure Q1(c)

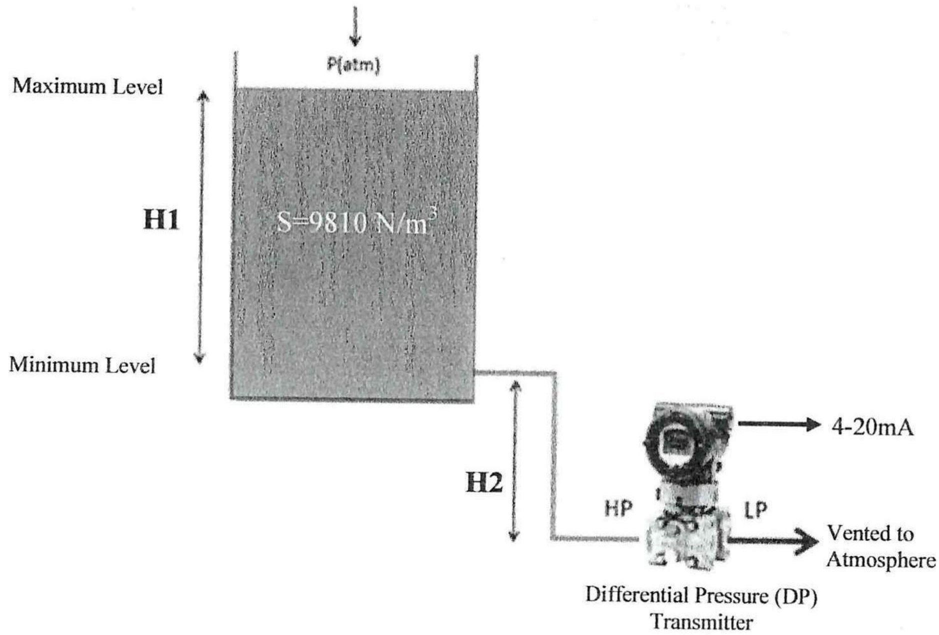

Figure Q2(b)

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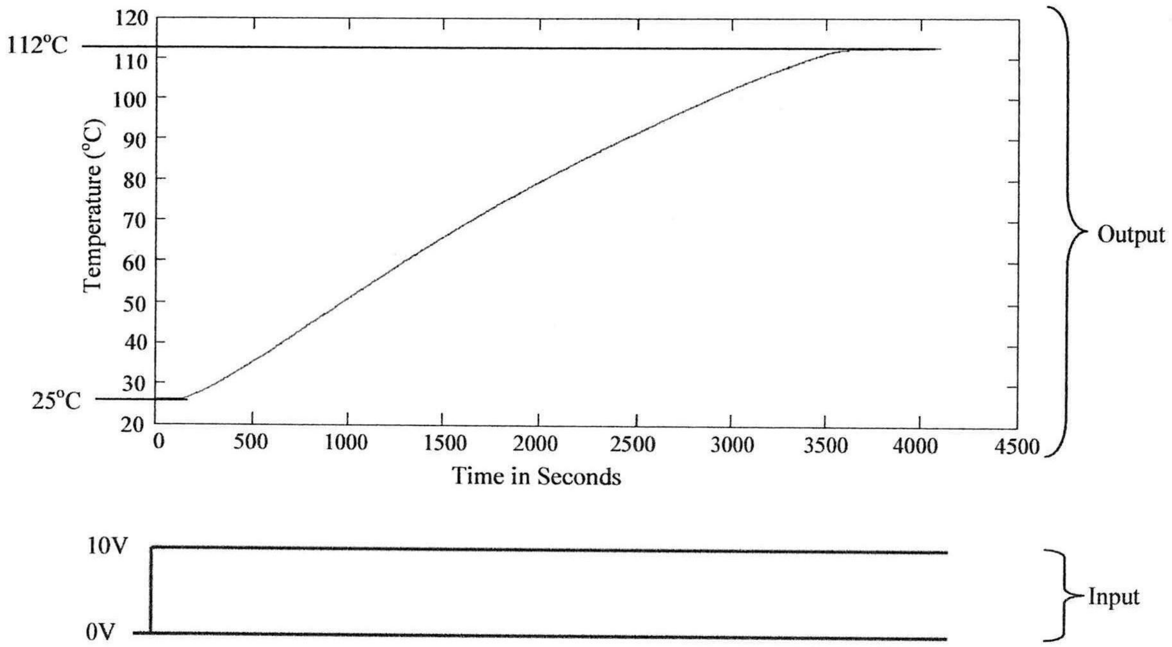

Figure Q4(b)

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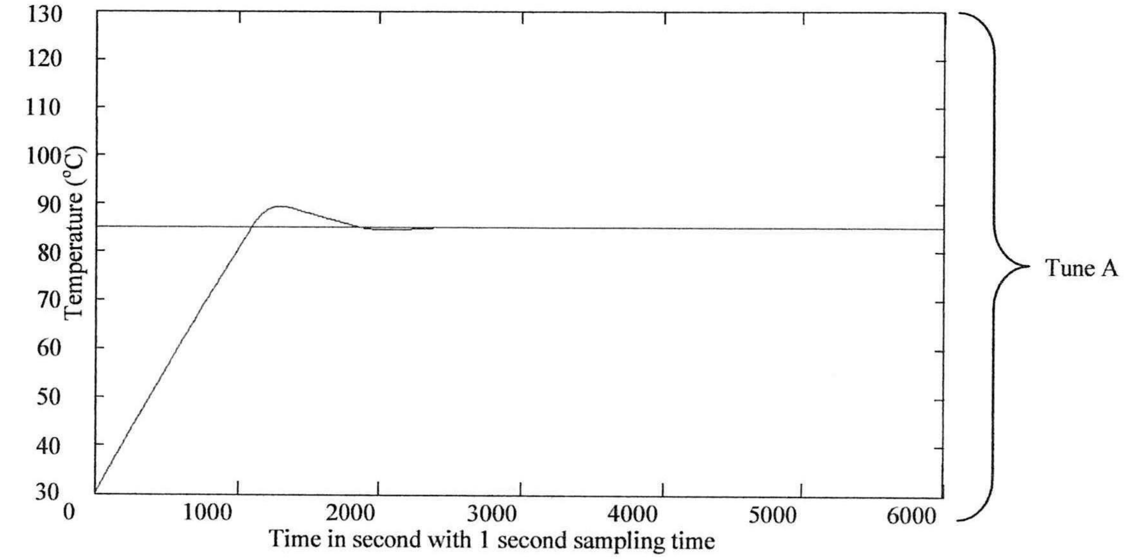

Figure Q5(a)(i)

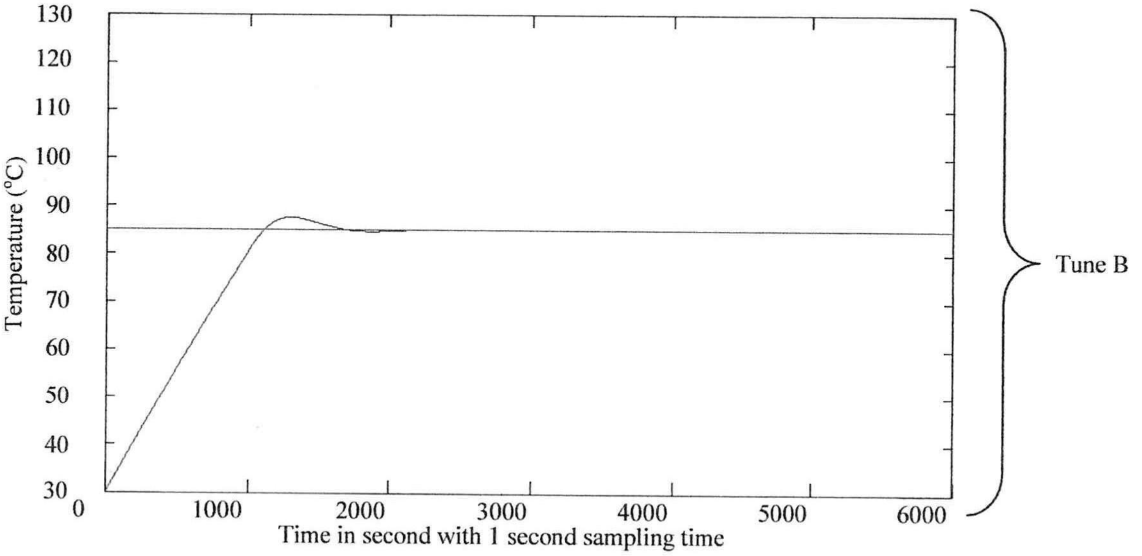

Figure Q5(a)(ii)

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Table Q5(b)

No	Set Point (SP) in ^{o}C	Process Variable (PV) in ^{o}C
1	75	75.012
2	75	75.101
3	75	75.072
4	75	75.066
5	75	74.993

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FORMULAE

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