Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2021/2022

COURSE NAME	:	CONTROL SYSTEM
COURSE CODE	:	DAE 32103
PROGRAMME CODE	:	DAE
EXAMINATION DATE	:	JANUARY / FEBRUARY 2022
DURATION	:	2 HOURS 30 MINUTES
INSTRUCTION	:	1. ANSWER **FOUR (4)** QUESTIONS. ONLY FROM **SIX (6)** QUESTIONS PROVIDED. 2. THIS FINAL EXAMINATION IS AN **ONLINE** ASSESSMENT AND CONDUCTED VIA **OPEN BOOK**

THIS QUESTION PAPER CONSISTS OF **TEN (10)** PAGES

Q1 (a) **Figure Q1(a)** shows a waste water treatment control system.

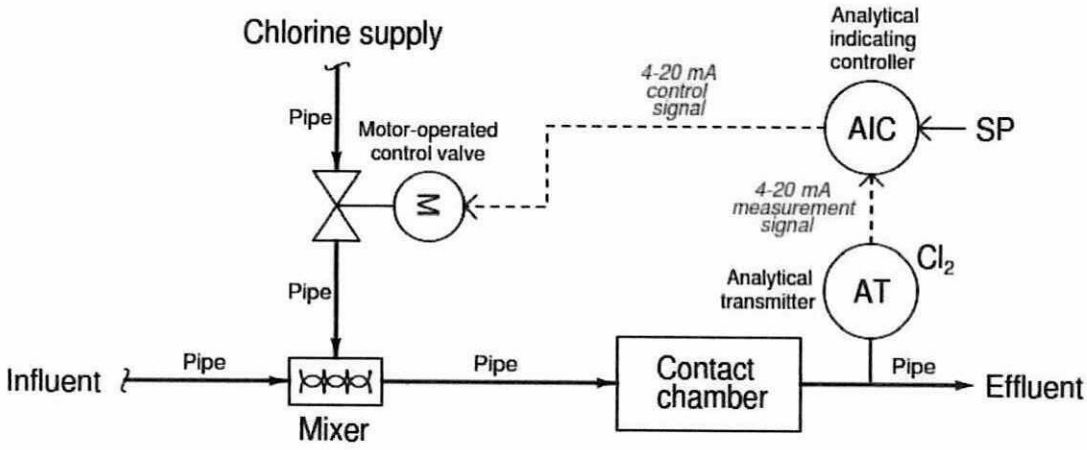


Figure Q1(a)

(i) Determine the controlled variable, manipulated variable and plant based on **Figure Q1(a)**.

(3 marks)

(ii) Draw the complete block diagram of the control system.

(6 marks)

(iii) Briefly discuss **two (2)** examples of disturbance that could affect the control system.

(4 marks)

(b) **Figure Q1(b)** shows a sprinkler irrigation system for agriculture purposes.

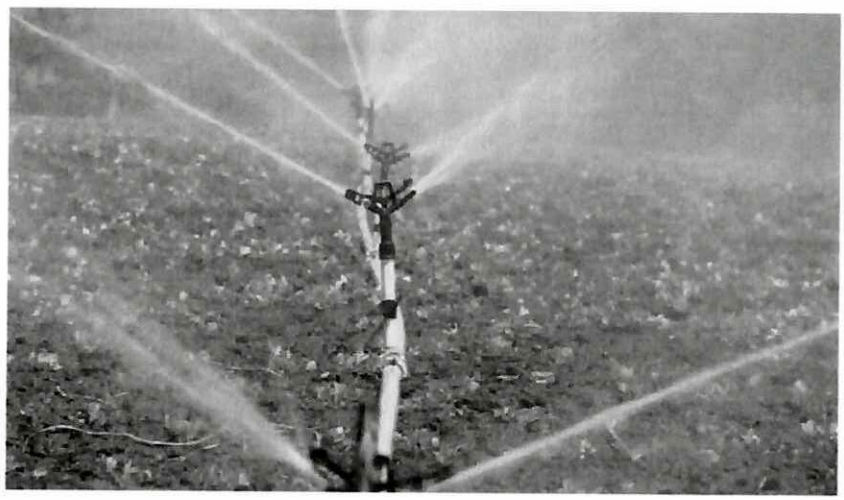


Figure Q1(b)

(i) Discuss the type of control system implemented to operate the sprinkler system.

(4 marks)

(ii) Determine the controlled variable, manipulated variable and plant based on **Figure Q1(b).**

(3 marks)

(iii) Draw the block diagram of the control system.

(5 marks)

Q2 (a) A ceiling fan control system is an example of open loop system. Describe in detail how to convert the system into closed loop system.

(4 marks)

(b) Find the transfer function, $G(s) = \frac{V_L(S)}{V(S)}$ for the circuit given in **Figure Q2(b).** Solve the problem using two methods, mesh analysis and nodal analysis to prove both methods yield the same results.

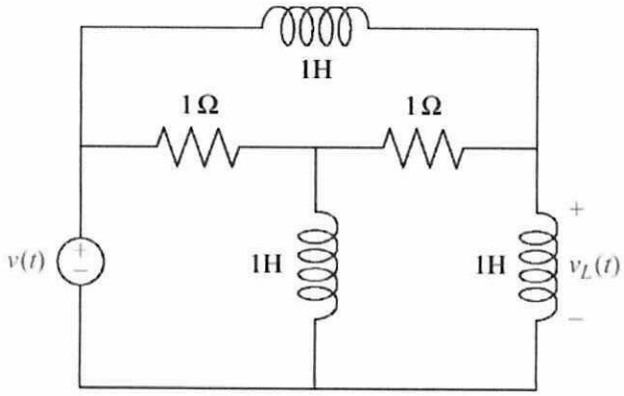


Figure Q2(b)

(12 marks)

(c) A second order control system with unity feedback has a damping ratio of 0.4 and natural frequency of 12 rad/s.

(i) Write down the closed loop transfer function for the system.

(2 marks)

(ii) Determine the stability of the system.

(3 marks)

(iii) Draw the step response of the system showing the values for rise time, peak time and settling time (2%).

(4 marks)

Q3 (a) **Figure Q3(a)** shows the rotational mechanical system that consists of mass, **three (3)** viscous dampers and spring.

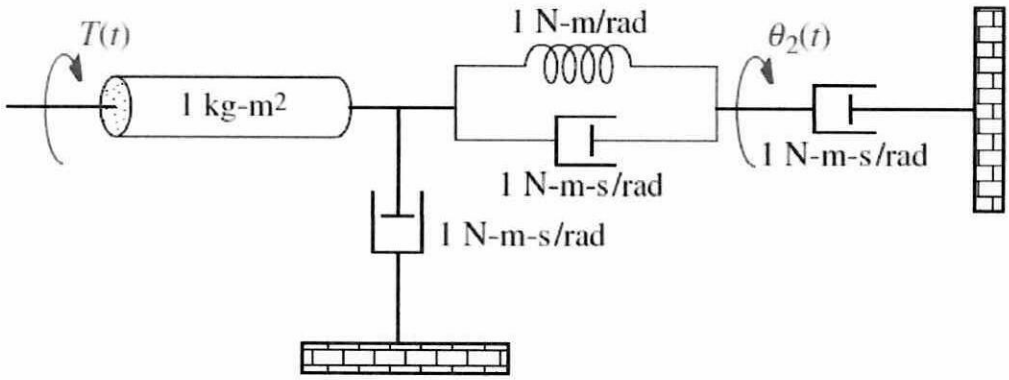


Figure Q3(a)

(i) Draw the free body diagram for the system.

(5 marks)

(ii) Based on the drawn free body diagram, construct the Laplace transform equation.

(5 marks)

(iii) Find the transfer function, $G(s) = \frac{\theta_2(s)}{T(s)}$.

(7 marks)

(b) There are several types of control system. Discuss two examples for SISO and MIMO system respectively by identifying the input and output implemented in the applications.

(8 marks)

Q4 (a) Give your opinion why digital control system is superior than analogue control system in terms of:

(i) Performance

(3 marks)

(ii) Cost

(3 marks)

(b) Determine the largest value of output voltage from an 8-bit DAC that produces 1.0 V for a digital input of 0011 0010.

(5 marks)

(c) Explain the function of Analog to digital converter (ADC) in digital control system.
(5 marks)

(d) **Figure Q4(d)** shows a digital ramp analog to digital converter (ADC). Assume the following values for the ADC; Clock frequency = 1 MHz and V_T = 0.1 mV. Meanwhile the DAC has F. S. Output = 10.23 V and a 10-bit input. Determine the following values.

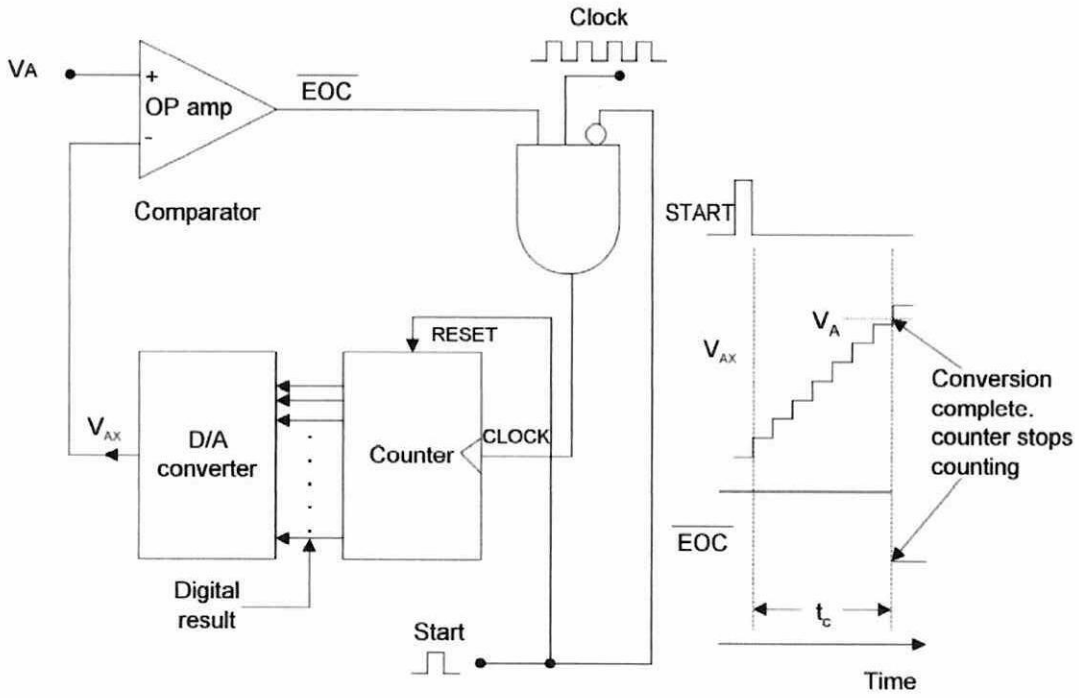


Figure Q4(d)

(i) The digital equivalent obtained for V_A = 3.728 V.
(3 marks)

(ii) The conversion time.
(3 marks)

(iii) The resolution of this converter.
(3 marks)

Q5 (a) **Figure Q5(a)** shows a Time Response for a second order system.

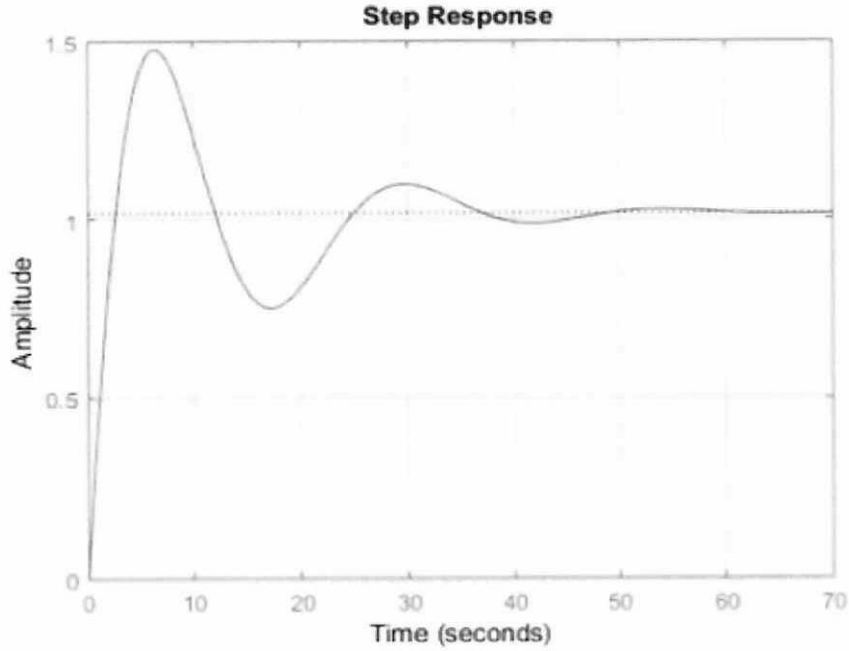


Figure 5(a)

(i) Determine Overshoot, Rise time, Peak time, Settling time and Steady state error from **Figure 5(a)**.

(5 marks)

(ii) Explain the effects of implementing a Proportional Integral Controller (PID) in **Figure 5(a)**.

(4 marks)

(b) Explain the working principle of Cascade control loop.

(4 marks)

(c) Sequential control is one type of process control system.

(i) Give **one (1)** example of system that operates in sequential control mode.

(2 marks)

(ii) Based on answer **Q5(c)(i)**, write the operation of sequential control mode of the system chosen.

(4 marks)

(iii) Interpret what can be happen if one of the processes in the sequential control mode fails to operate.

(2 marks)

(d) The P (proportional) controller block diagram for temperature regulation for steam distillation is as shown in **Figure Q5(d)**.

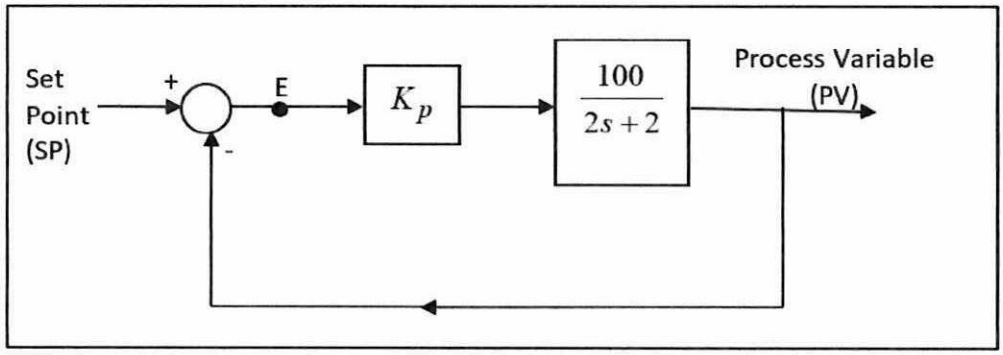


Figure Q5(d)

Interpret the operation of the system when:

(i) $E > 0$

(2 marks)

(ii) $E < 0$

(2 marks)

Q6 (a) Measurements are important in process control industry since it use for feedback element for controlling the process.

(i) List **one (1)** type of measurement in process control.

(1 mark)

(ii) Based on any process (chosen by student) related with the measurement chosen in **Q6(a)(i)**, sketch the feedback schematic diagram for the process to illustrate the implementation of measurement (chosen in **Q6(a)(i)**) for feedback control.

(6 marks)

(iii) Write the operation of the system sketched in **Q6(a)(ii)**.

(3 marks)

(b) **Figure Q6(b)** shows unity feedback system use by YokNgombeNgombe Sdn. Bhd. for controlling temperature of steam distillation process. For improvement, the company plan to implement PID controller for controlling the temperature of the process.

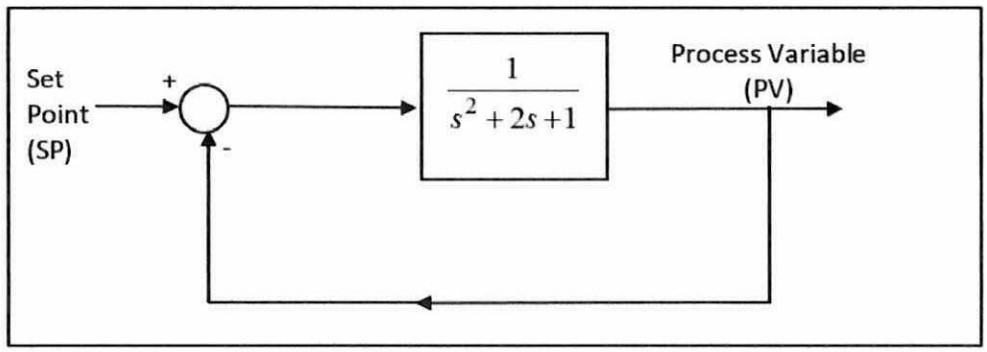


Figure Q6(b)

(i) Sketch PID controller block diagram for the system when the parameters of the controller are given as follows:

Proportional, Kp = 5
Integral, Ki =1
Derivative, Kd = 2

(5 marks)

(ii) Based on the block diagram sketch in **Q6(b)(i)**, solve the closed loop transfer function for the system.

(4 marks)

(iii) If the Set Point (SP) = 85 °C and Process Variable (PV) = 79 °C, interpret the operation of the system.

(2 marks)

(iv) Describe the function of Proportional component and Integral component in PID controller.

(4 marks)

– END OF QUESTIONS –

FINAL EXAMINATION

SEMESTER / SESSION : SEM 1 2021/2022
COURSE NAME : CONTROL SYSTEM
PROGRAMME CODE : DAE
COURSE CODE : DAE 32103

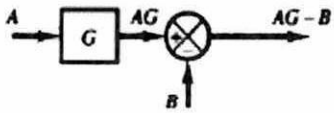
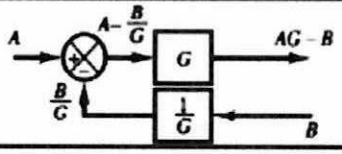
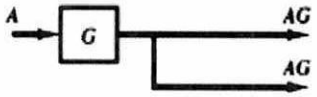
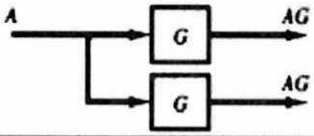
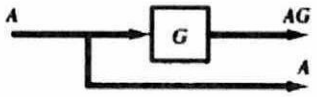
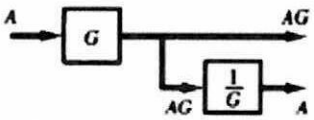
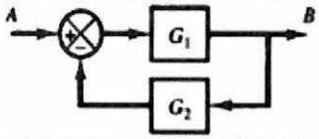
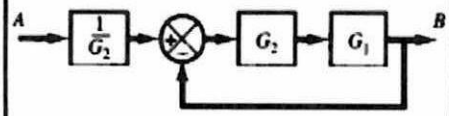
LIST OF FORMULAE: Laplace Transform Table

f(t), t ≧ 0	**F(s)**
1. $\delta(t)$	1
2. $u(t)$	$\frac{1}{s}$
3. t	$\frac{1}{s^2}$
4. t^n	$\frac{n!}{s^{n+1}}$
5. e^{-at}	$\frac{1}{s+a}$
6. te^{-at}	$\frac{1}{(s+a)^2}$
7. $t^n e^{-at}$	$\frac{n!}{(s+a)^{n+1}}$
8. $\sin bt$	$\frac{b}{s^2+b^2}$
9. $\cos bt$	$\frac{s}{s^2+b^2}$
10. $e^{-at}\sin bt$	$\frac{b}{(s+a)^2+b^2}$
11. $e^{-at}\cos bt$	$\frac{s+a}{(s+a)^2+b^2}$
12. $t\sin bt$	$\frac{2bs}{(s^2+b^2)^2}$
13. $t\cos bt$	$\frac{s^2-b^2}{(s^2+b^2)^2}$

FINAL EXAMINATION

SEMESTER / SESSION : SEM 1 2021/2022
COURSE NAME : CONTROL SYSTEM
PROGRAMME CODE : DAE
COURSE CODE : DAE 32103

LIST OF FORMULAE: Block Diagram Transformation

	Original Block Diagrams	Equivalent Block Diagrams
1		
2		
3		
4		
5