PP2

TECHNICAL UNIVERSITY OF MOMBASA

School of Engineering and Technology

Department of Electrical and Electronic Engineering

UNIVERSITY EXAMINATION FOR:

Bachelor of Technology in Electrical Engineering

TEE 4318: PROCESS CONTROL SYSTEMS

END OF SEMESTER EXAMINATION

SERIES: JULY 2025 EXAM

TIME: 2 HOURS

DATE: July 2025

Instructions to Candidates

You should have the following for this examination

-Answer Booklet, examination pass and student ID

This paper consists of **five** Questions. Attempt any **THREE** Questions.

Do not write on the question paper.

Question ONE

(a) Figure Q 1(a) is a schematic of an oven control system.

i) State whether the control system is open loop or closed loop

ii) Give the controlled variable

iii) State the manipulated variable

iv) State what is being used as the final control element

v) State any one possible source of disturbance to the system

(5 marks)

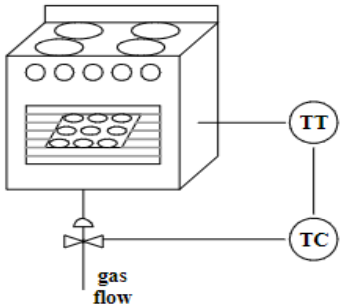

Figure Q 1 (a)

(b) Distinguish between supervisory control and direct digital control as applied in digital process control systems hence draw process control loops for systems employing:

i) Computer Supervisory control

ii) Direct digital control (DDC)

(8 marks)

(c) State any two practical applications of on-off controllers
(d) Explain the following terms: -
   i) Neutral zone
   ii) Proportional band
   iii) Offset error

(3 marks)

(e) State what is meant by reset windup or integral windup associated with integral control action (2 marks)
(f) Give reasons why derivative control action is not used alone (2 marks)

Question TWO

(a) Sketch the input – output characteristic of single – speed floating controller and give any two limitations of single speed floating control. (6 marks)
(b) Sketch Pneumatic P + I controller and explain how the control actions are realized (6 marks)
(c) Plot the graph of a proportional-integral controller output as a function of time for a hypothetical error signal of figure Q2 (c) given that $K_p = 5$, $K_I = 1.0s^{-1}$, and $U_I(0) = 20\%$ (8 marks)

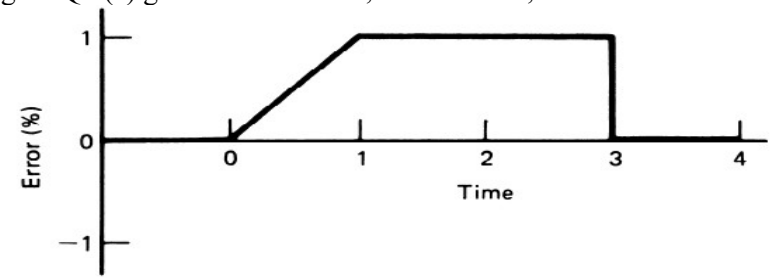

Figure Q 2(c)

Question THREE

(a) Explain what is meant by self-regulating process. (2 marks)
(b) Distinguish between the following:
   i) Lumped and Distributed parameter models
   ii) Continuous processes and Batch processes

(4 marks)

(c) Define the following terms
   i) process load
   ii) process lag,
   iii) self-regulation

(3 marks)

(d) Describe three criteria to evaluate the performance of a process-control loop. (3 marks)
(e) Develop a model for the simple thermal system of a thermometer at temperature T being used to measure the temperature of a liquid when it suddenly changes to the higher temperature of T_L as shown in Figure Q1 (f).

(6 marks)

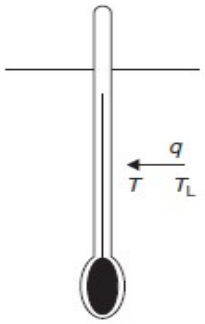

Figure Q1 (f)

(f) Explain the process of control valve size determination (valve sizing). (2 marks)

Question FOUR

(a) Describe how the nozzle/flapper system in conjunction with bellows can be used to implement proportional plus integral plus derivative control using pneumatics. (6 marks)

(b) Enumerate the steps involved in the Ziegler-Nichols closed-loop tuning method. (6 marks)

(c) The Ziegler-Nichols open-loop tuning method was used to obtain the process response in Figure Q4 (c). Find the tuning parameters for a serial PID controller given that the control variable change that caused this response was 11%. (8 marks)

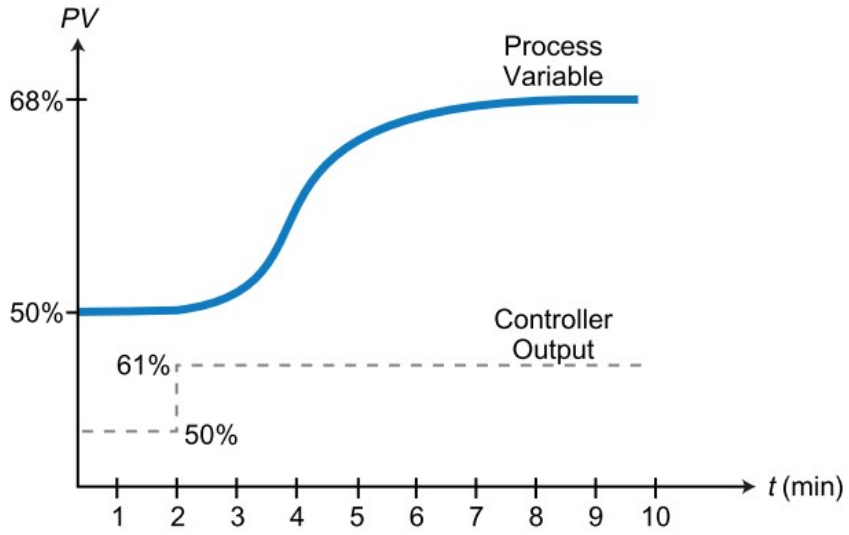

Figure Q 4 (c)

Question FIVE

(a) Suppose a force of 400 N must be applied to open a valve. Find the diaphragm area required if a control gauge pressure of 70 kPa must provide this force. (2 marks)

(b) An equal percentage valve has a maximum flow of 50 cm^3/s and a minimum of 2 cm^3/s. If the full travel is 3 cm, find the flow at a 1- cm opening. (2 marks)

(c) State advantages and disadvantages of feed forward control schemes (4 marks)

(d) Distinguish between override control and split-range control (2 marks)

(e) Draw a block diagram to illustrate each of the following control schemes.

i) cascade control

ii) Ratio control

(10 marks)

Type of Controller	Loop Tuning Constant	Tuning Equation
Proportional (P)	K_P	$K_P = \frac{\Delta CV}{(L_t)(N)}$
Proportional-Integral (PI)	K_P	$K_P = \frac{(0.9)(\Delta CV)}{(L_t)(N)}$
	T_I	$T_I = (3.33)(L_t)$
Proportional-Integral-Derivative (PID)	K_P	$K_P = \frac{(1.2)(\Delta CV)}{(L_t)(N)}$
	T_I	$T_I = (2)(L_t)$
	T_D	$T_D = (0.5)(L_t)$

Ziegler-Nichols open-loop tuning equations.