



UNIVERSITI KUALA LUMPUR
MALAYSIAN INSTITUTE OF CHEMICAL AND BIO-ENGINEERING TECHNOLOGY

FINAL EXAMINATION
OCTOBER 2025 SEMESTER

COURSE CODE : CQB 21103
COURSE TITLE : PROCESS INSTRUMENTATION AND CONTROL
PROGRAMME NAME : BACHELOR OF FOOD SAFETY AND QUALITY TECHNOLOGY WITH
HONOURS
DATE : 31 JANUARY 2026
TIME : 9:00AM - 12:00PM
DURATION : 3 HOURS

INSTRUCTIONS TO CANDIDATES

1. Please read the instructions given in the question paper CAREFULLY.
2. This question paper is printed on both sides of the paper.
3. This question paper consist of TWO sections.
4. Answer ALL questions for Section A.
5. Section B consist of four questions. Answer THREE (3) questions only.
6. Please write your answer on the answer booklet provided.
7. Please answer all questions in English only.
8. Please answer MCQ/EMQ questions using OMR sheet. ☐ *Tick if applicable*
9. Refer to the attached Formula/ Appendies. ☐ *Tick if applicable*

SECTION A (Total: 40 marks)

Answer ALL questions.

Please use the answer booklet provided.

Question 1

Answer all the question.

- (a) Complete the table below by filling in the missing principles and/or descriptions for each instrumentation device.

Refer Below - Table1 : Principle of instrument .

(5 marks)

Table 1: Principle of instrument

Device	Principle	Description
Mercury thermometer		Measures temperature based on the uniform expansion of mercury inside a sealed glass tube as temperature changes.
Capacitance level measurement	Change in capacitance	
Bourdon gauge		Measures pressure by the elastic deformation of a curved metal tube that straightens when internal pressure increases.
Orifice flow meter	Differential pressure (Bernoulli's principle)	
Thermocouple		Measures temperature by generating a voltage when two dissimilar metals are joined and subjected to a temperature difference.

- (b) The temperature readings indicated by various temperature measurement devices (TI1-thermocouple, TI2-RTD, bimetallic thermometer, and mercury thermometer) are shown in Table 1. Determine the instrument with the erroneous measurement and explain the reason.

Refer Below - Table2 : Temperature Monitoring .

(3 marks)

Table 2: Temperature Monitoring

TI 1	TI2	Bimettalic thermometer	Mercury thermometer
29.8°C	28.8°C	31°C	30°C
40.1°C	30.1°C	39°C	40°C
49.6°C	30.2°C	50°C	50°C

- (c) Describe the function of the electrical heater.

(4 marks)

- (d) Sketch the diagram for the butterfly valve.

(3 marks)

- (e) Explain three regular activities to maintain an instrument.

(3 marks)

- (f) State the definition of calibration.

(2 marks)

Question 2

Complete all questions.

- (a) Explain the basic concept of measurement and its importance in food quality applications.

(5 marks)

- (b) Describe three common issues of control system malfunction.

(2 marks)

- (c) Complete the table by identifying the correct term or concept that best matches each description related to basic process control and instrumentation

Refer Below - Table3 : Key concept of process control .

(8 marks)

Table 3: Key concept of process control

Description	
A device that converts a control signal into physical motion to operate a final control element	
A type of controller that combines proportional, integral and derivative actions.	
The process variable that is measured and maintained at a desired set point	
A control valve commonly used to regulate flow due to its good throttling capability	
The manipulated variable typically controlled in a damper.	
The main control loop that regulates the primary process variable in a cascade control system	
The abbreviation for "P only" refers for	
A control valve characteristic where equal changes in valve position result in equal percentage changes in flow	

- (d) Describe on the cascade control system.

(5 marks)

SECTION B (Total: 60 marks)

Answer THREE (3) questions only.

Please use the answer booklet provided.

Question 1

Raw milk undergoes a UHT (Ultra-High-Temperature) processing sequence to produce UHT milk. The key stages are summarized as follows:

Milk Reception and Filtration: Raw milk is received and filtered to remove debris and impurities.

Preheating: The milk is preheated in a plate heat exchanger to approximately 50–60°C using warm water.

Homogenization: The preheated milk is homogenized to achieve uniform fat distribution and improved product stability.

UHT Sterilization: Milk is heated to 72°C for 15–20 **seconds** using a plate heat exchanger to destroy pathogenic microorganisms.

Cooling: The milk is rapidly cooled to ~4°C using chilled water to prevent microbial growth.

Storage: The pasteurized milk is transferred to chilled storage tanks before packaging.

Draw both the Process Flow Diagram (PFD) and the Process and Instrumentation Diagram (P&ID) for the pasteurized milk production process.

(20 marks)

Question 2

The process involves purifying raw water and preparing it for bottling. The steps are as follows:

Fruit Washing and Crushing: Fresh fruits are fed into a washing unit to remove dirt and impurities. Cleaned fruits are then sent to a crusher where they are crushed into pulp.

Pulp Heating: The crushed fruit pulp is pumped into a pulp heater (heat exchanger) where it is heated to 85°C for pasteurization. A hot water line supplies heat to the exchanger.

Separation and Filtration: After heating, the pulp passes through a centrifugal separator to remove solids and unwanted particles. The clarified juice is sent to a filtration unit for fine filtration.

Cooling: The filtered juice is cooled in a cooling unit (heat exchanger) using chilled water, reducing the temperature to 5°C for storage.

Storage: The cooled juice is pumped into a storage tank, ready for bottling.

Based on the process described above, recommend the appropriate instrumentation required for each stage of the process.

Your answer should include:

The required measurements (e.g. flow, temperature, pressure, level, or quality)

The purpose of monitoring and control for product quality and safety

The appropriate type of instrument, sensing principle, and installation location

(20 marks)

Question 3

Answer the questions below.

- (a) In a dairy processing plant, a cooling process is used to chill pasteurized milk before it is transferred to the storage tank. Product temperature must be maintained below 5 °C to prevent microbial growth and ensure product safety.

The system uses the following components:

Primary Process Variable (PV): Outlet temperature of the milk at the cooling unit.

Actuator: A solenoid valve that controls the flow of chilled glycol into the heat exchanger.

Final Control Action: The valve operates in an **on-off mode** — fully open when cooling is required and fully closed when the desired temperature is reached.

- i. Explain how an on-off control system works in the context of this cooling process.

(3 marks)

- ii. Analyze the possible reasons for the performance issues observed.

(3 marks)

- iii. Discuss the suitability of using on-off control for this type of food cooling process and propose improvements or alternative actions that could enhance temperature regulation.

(4 marks)

- (b) In a pasteurization process, the outlet temperature of the product is controlled using a PID controller. A step change is applied to the setpoint, and the process response is recorded as shown in the graph below:

Refer Below - Figure1 : Process Response .

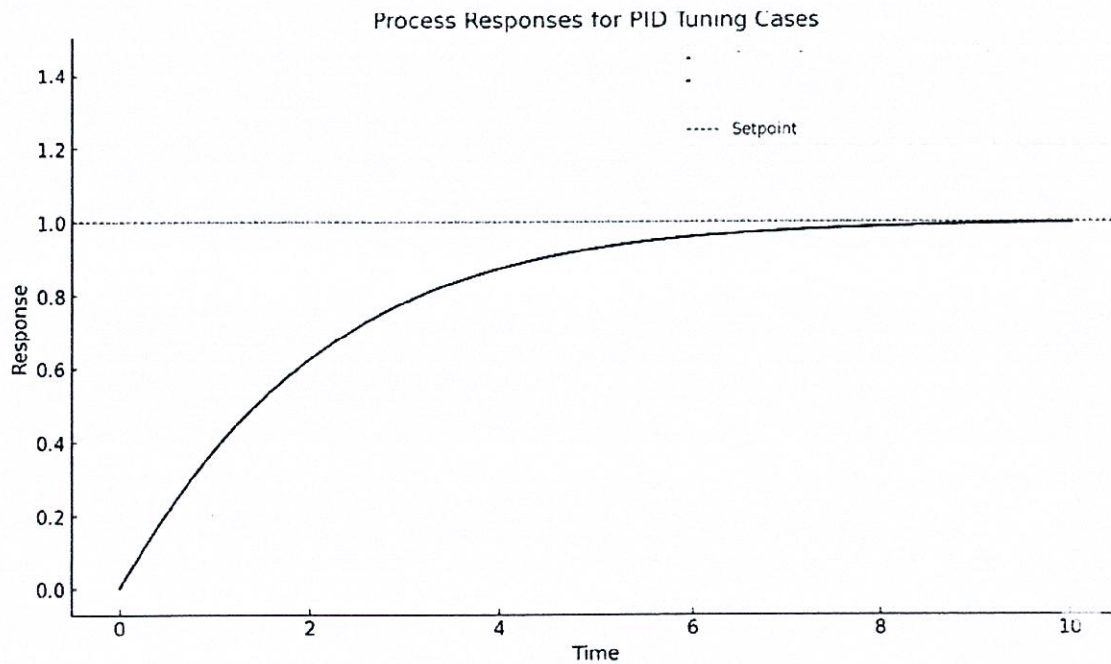


Figure 1: Process Response

- i. Explain the likely influence of Proportional (P), Integral (I), and Derivative (D) actions on this type of response.
(5 marks)
- ii. Suggest one modification to the PID tuning that could improve the system response if the process shows slower response or small steady-state error.
(5 marks)

Question 4

An investigation was performed, and the specifications of the existing temperature transmitter are shown below:

Existing Instrument (TT-101) Specification

Measurement Range: 0–100 °C

Accuracy: ± 0.5 °C

Output Signal: 4–20 mA

Sensor Type: Pt100 (RTD)

Process Connection: Tri-clamp sanitary fitting

Response Time: 1.5 seconds

Age of Instrument: 7 years

The manager must decide whether to repair the existing instrument or purchase a replacement. Three vendor options and one repair service have submitted quotations:

Vendor A (New Instrument):

Range: 0–80 °C, Accuracy: ± 0.3 °C, Response Time: 1.0 s, Price: RM 2,800

Vendor B (New Instrument):

Range: 0–120 °C, Accuracy: ± 0.2 °C, Response Time: 0.8 s, Price: RM 3,900

Vendor C (New Instrument):

Range: 0–100 °C, Accuracy: ± 0.15 °C, Response Time: 0.6 s, Price: RM 5,200

Repair Service (Existing Instrument):

Calibration + RTD Sensor Replacement + Testing

Total Cost: RM 1,200, Warranty: 6 months

- (a) Evaluate the instrumentation problem described in the scenario, identifying the likely causes of the incorrect readings and discussing the potential operational impacts.

(10 marks)

- (b) Compare and justify whether to repair the existing transmitter or purchase a replacement, using both technical and economic criteria. Provide a final recommendation and justify the choice for the operations manager.

(10 marks)

END OF EXAMINATION PAPER

