



**UNIVERSITI TUN HUSSEIN ONN MALAYSIA**

**FINAL EXAMINATION  
SEMESTER I  
SESSION 2019/2020**

COURSE : INSTRUMENTATION FOR  
PROCESS CONTROL

COURSE CODE : BEF 45902

PROGRAMME CODE : BEV

EXAMINATION DATE : DECEMBER 2019 / JANUARY 2020

DURATION : 2 HOURS 30 MINUTES

INSTRUCTION : ANSWER ALL QUESTIONS

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THIS QUESTION PAPER CONSISTS OF **SIX (6)** PAGES

- Q1** (a) Process control can be defined as the act of controlling a final control element to change the manipulated variable for maintaining the process variable at a desired set point. As an engineer,
- List **four (4)** manipulated variables commonly used in a process control (4 marks)
  - Discuss **two (2)** importance of process control. (4 marks)
- (b) Consider the process flow diagram shown in **Figure Q1(b)**, where a fluid stream from process 1 is fed to the surge tank. The effluent from the surge tank is sent to process 2. The control objective is to maintain the height within certain bounds.
- With the help of an appropriate illustration, briefly describe a feedback control strategy to achieve the desired process control objective. (5 marks)
  - Draw a schematic block diagram for the proposed in strategy **Q1(b)(i)**. (3 marks)
- (c) **Figure Q1(c)** shows an oil flow in a pipeline, equipped with orifice plate with  $K = 119.5$  (gal/min) / psi<sup>1/2</sup>. The oil flow is to be maintained for a certain flow range. The pressure gauge with an LVDT is calibrated so that the output is 1.8 V/psi. Determine the range of oil flow (gal/min) in the pipeline if the LVDT is giving a voltage range between 0.0504V and 2.836V. (6 marks)
- (d) For a thermocouple device, determine the terminal voltage of the thermocouple with  $\alpha=40\mu\text{V}/^\circ\text{C}$  if the junction temperature are 40 °C and 80 °C. (3 marks)
- Q2** (a) Identify **two (2)** main components of a control valve (2 marks)
- (b) A mineral water is pumped through a pipe of 15-cm diameter at a flow velocity of 3 m/s. Find the volume flow rate. (3 marks)
- (c) Spring and diaphragm is one of common actuator type used in practice to control valve body.
- Suggest **two (2)** advantages and disadvantages of this type of actuator as compared to others. (4 marks)

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- ii) Suppose a force of 400 N must be applied to fully open a valve. Determine the diaphragm diameter if a control gauge pressure of 70 kPa (~10 psi) is to provide the required force. (4 marks)
- (d) Valves are susceptible to flashing and cavitation during operation. Describe cavitation phenomenon and explain how it could lead to the aging and deterioration. (3 marks)
- (e) A control valve is operated under the following conditions:
- vapor pressure of the flowing liquid is 0.7 psi,
  - vane contraction pressure at choke flow is 0.665 psi,
  - inlet valve pressure is 40 psi,
  - outlet valve pressure is 15 psi and
  - valve recovery coefficient is 0.5.
- i) Analyse whether the valve will activate under these service condition. (5 marks)
- ii) If the actual  $\Delta P$  is maintained at 25 psi, determine the inlet valve pressure so that the valve will not cavitate. (4 marks)
- Q3** (a) With the help of an appropriate illustration, define '*signal conditioning*' in the context of instrumentation and process control engineering. (4 marks)
- (b) A temperature is to be measured in the range of 0 °C to 250 °C. The sensor is a resistance that varies linearly from 60  $\Omega$  to 300  $\Omega$  for this temperature range. The power dissipated in the sensor must be kept below 5 mW.
- i. Determine the transfer function of the signal conditioning that provides a voltage varying linearly from 1 to 5 V for this temperature range. (7 marks)
- ii. Determine the current flow in the sensor at maximum temperature so that the maximum power dissipated in the sensor is 5 mW. (4 marks)

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- (c) A measurement of a liquid level using an ultrasonic circuit has output of 6.5 mV/cm. A circuit to measure up to 100 cm with a 6-bit ADC and a 10 V reference is applied.
  - i. Determine the gain index for the amplifier circuit between the sensor and the ADC. (7 marks)
  - ii. Predict the voltage appears at the input of ADC, if temperature is 15°C. (3 marks)

- Q4**
- (a) Draw symbols that are used in ladder diagram for relay, motor, switch and light. (4 marks)
  - (b) Design a basic structure of a programmable logic controller (PLC) system. (4 marks)
  - (c) A liquid level control is shown in **Figure Q4(c)**. Pump will run when the liquid is below the low level,  $L_E$  and pump will stop when the liquid is above the high level,  $L_{UP}$ . Initially the tank is empty. The control system is added with the start push-button, the stop push-button and the pump motor starter. Design the ladder diagram of the liquid level control process of this system. (11 marks)
  - (d) Describe **three (3)** benefits of the PLC (SCADA) system as compared to the traditional approaches. (6 marks)

- END OF QUESTIONS -

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From process 1

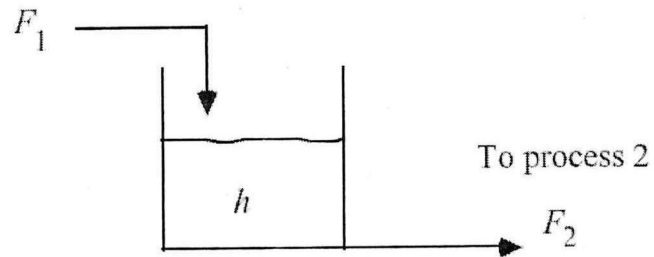


Figure Q1(b)

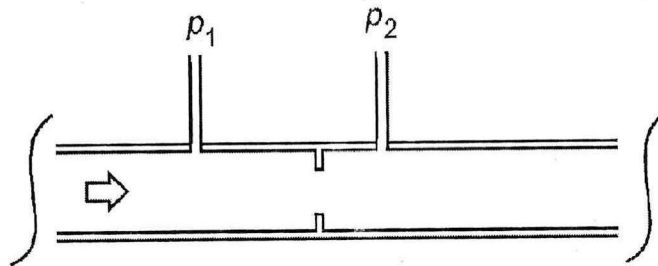


Figure Q1(c)

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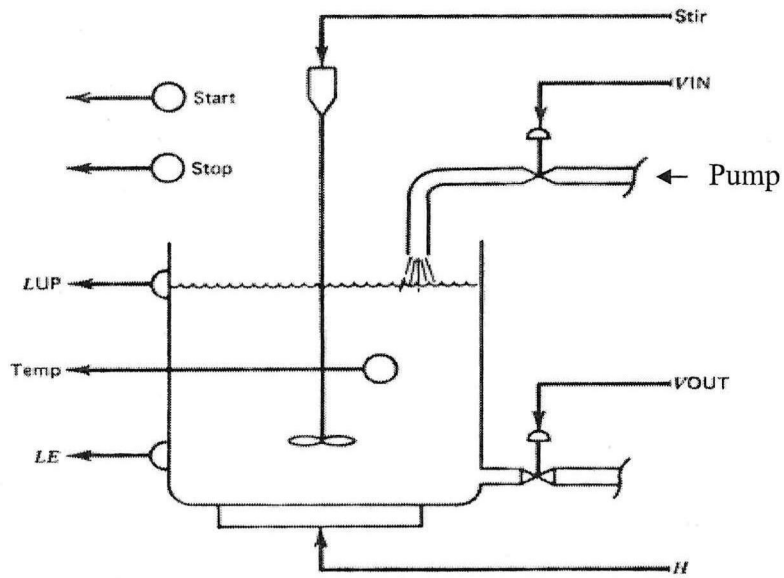


Figure Q4(c)

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