First Semester Examination
2022/2023 Academic Session

February 2023

EMC 311 – Mechatronic
(Mekatronik)

Duration: 2 hours
(Masa: 2 jam)

Please check that this examination paper consists of SEVEN (7) pages of printed material before you begin the examination.

[Sila pastikan bahawa kertas peperiksaan ini mengandungi TUJUH (7) muka surat yang bercetak sebelum anda memulakan peperiksaan ini].

Instructions : Answer **ALL FIVE (5)** questions.

*[**Arahan :** Jawab **KESEMUA LIMA (5)** soalan.]*

…2/-

1. [a] In mechatronics system, there are several important elements as listed in 1 [a](i) – [a](iv). Provide ONE (1) example and explain the function of each listed elements.

(i) Sensor

(ii) Actuator

(iii) Microprocessor

(iv) System

(40 marks)

[b] Figure 1[b] shows the feedback control block diagram of a water tank system.

(i) With the help of water tank sketch, draw and label the a – i elements of the block diagram.

(ii) Based on answer in 1[b](i), explain the function of each elements a – i in a Table form.

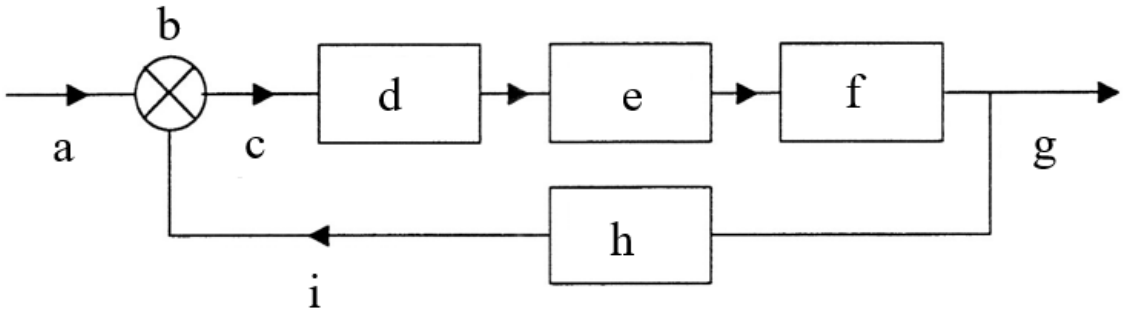

Figure 1[b]

(60 marks)

2. [a] Pneumatic system is commonly used in various mechatronic systems in real life application. For example, to move an object on conveyor in manufacturing industry.

(i) Draw and label the overall architecture of a pneumatic system.

(ii) Based on answer in 2 [a](i), explain the function of each element of pneumatic system in a Table form.

(50 marks)

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[b] In manufacturing industry, a process control valve is usually used to control the rate of fluid flow through the system.

(i) In this case, the actuator has a stem movement which at full travel is 30 mm. It is mounted on a process control valve with an equal percentage plug that has a minimum flow rate of 2 m^3/s and a maximum flow rate of 24 m^3/s. Determine the flow rate when the stem movement is 10 mm. Based on the stem displacement vs flow rate plot, prove that your answer is appropriated.

(ii) In process control valve, other important parameter is to choose the correct size of valve body based on the flow coefficient value. Determine the valve size that required to control the flow of water when the maximum flow required is 0.012 m^3/s and the permissible pressure drop across the valve is 300 kPa. Also, please justify why the valve size is selected.

(50 marks)

3. [a] (i) Explain ONE (1) main advantage of Programmble Logic Controller (PLC) compare to other electronic control circuit.

(5 marks)

(iii) What are the THREE (3) basic components in PLC?

(15 marks)

[b] Your cousin will have a wedding next week in the village and you were task to prepare the beverage for the guests. The beverage chosen is rose cordial mix with plain water as shown in Figure 3[b]. As a future engineer, you know the process of the mixing of the two liquids can be automate and the mixing machine can be benefited by other villagers in the future. In your garage, you have electronic parts and actuator that can be used for this project. The list of part that are available are:

1. Switches
2. Level sensors
3. Pumps
4. Mixer
5. Timer
6. Omron PLC

…4/-

Figure 3[b]

(i) Using the parts given, draw the schematic diagram for the mixing tank.

(20 marks)

(ii) From information that you get from other villagers, you found that for perfect mixing, the ratio of concentrated rose cordial with plain water is 1:1 and the mixing time is 20s. When the level of the liquid in the mixing tank drops to the minimum set level, the mixing process will trigger again thus start the new cycle. For safety measure, the stop button will shut down the whole system when pressed.

Based on the diagram your draw in 3b[i], construct the ladder logic diagram for this operation and explain the program for each rung.

(60 marks)

4. [a] Figure 4[a] shows a combination of three NOR gates.

(i) Draw a truth table and a boolean expression that describes the operation of a digital circuit in Figure 4[a]. (Hint: Use De Morgan's laws.)

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(ii) Draw an electrical circuit diagram (compose of a battery, switches, a light bulb, etc..) that can represent the truth table in 4[a](i). (Hint: Only consider *A*, *B*, and *Q*. Ignore *C* and *D*.)

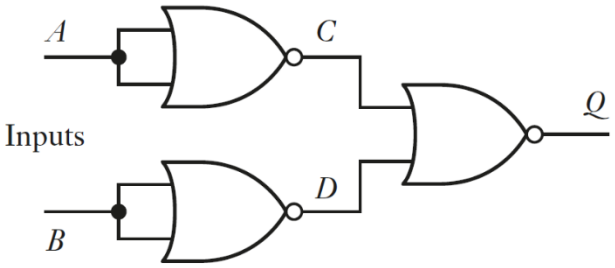

Figure 4[a]

(30 marks)

[b] Table 4[b] shows a truth table where the inputs are *A*, *B*, and *C*, and the output is *Q*.

(i) Draw a Karnaugh map based on the truth table and determine the boolean expression.

(ii) Assuming complements of *A*, *B* and *C* are not available, implement the boolean expression in Q4[b](i) by using only one-input and two-input gates. (Note: Please label your gates to prevent misread.)

Table 4[b]

A	B	C	Q
0	0	0	0
0	0	1	0
0	1	0	1
0	1	1	0
1	0	0	1
1	0	1	1
1	1	0	1
1	1	1	0

(30 marks)

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5. [a] Thyristor and TRIAC has a similar characteristic in the gate controlling condition.

(i) Recall the characteristic I-V curve of both devices, draw and explain both gate controlling condition characteristics.

(ii) Recall the effect that occurs when a sinusoidal voltage is applied to both devices, draw the voltage plot of the effect for both devices.

(40 marks)

[b] Explain the reason why a brushless direct current (BLDC) motor is categorised as a dc motor and give THREE (3) advantages of BLDC over the brushed DC motors and the induction motors.

(**20 marks**)

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APPENDIX 1

Valve size selection based on the flow coefficient

Pemilihan saiz injap berdasarkan pekali aliran

Flow coefficients	Valve size (mm)							
	480	640	800	960	1260	1600	1920	2560
C_V	8	14	22	30	50	75	110	200
$A_V \times 10^{-5}$	19	33	52	71	119	178	261	474

…8/-