



UNIVERSITI TUN HUSSEIN ONN MALAYSIA

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

COURSE NAME : REAL TIME EMBEDDED SYSTEM
COURSE CODE : BEH 42003
PROGRAMME CODE : BEJ
EXAMINATION DATE : DECEMBER 2019/ JANUARY 2020
DURATION : 3 HOURS
INSTRUCTION : ANSWER ALL QUESTIONS

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THIS QUESTION PAPER CONSISTS OF **FOUR (4)** PAGES

- Q1** (a) Give a definition of real-time system. (2 marks)
- (b) Explain the following terminology in real time systems.
(i) Job
(ii) Task (4 marks)
- (c) Discuss **THREE (3)** criterias that you would apply when choosing the right RTOS for your embedded microcontroller system. (6 marks)
- Q2** (a) Explain the general purpose of setup() and loop() functions in Arduino microcontroller system. (4 marks)
- (b) Two (2) LEDs and a push button switch are connected to digital D2, D3 and D4 of an Arduino Uno microcontroller. The following is a complete C-programming code of the system.

```
void setup()
{
  pinMode(2,OUTPUT); //LED1
  pinMode(3,OUTPUT); //LED2
  pinMode(4,INPUT); //BTN
}

void loop()
{
  if(digitalRead(4)== LOW) //BTN Pressed
  {
    digitalWrite(2, HIGH); //LED1 ON
    digitalWrite(3, HIGH); //LED2 OFF
  }
  else
  {
    digitalWrite(2, LOW);
    digitalWrite(3, LOW);
  }
}
```

- (i) Describe the operation of the system. (4 marks)
- (ii) Analyze the coding and sketch the suitable schematic of microcontroller interface between LEDs and the push button. (10 marks)

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- Q3** (a) Compare **THREE (3)** common data transmission approaches in serial communication in embedded system. (6 marks)
- (b) Two type of input and output (I/O) expander chip can be selected for extending our input/output peripheral which are MCP23017 and MCP23S17. The MCP23017 uses inter-integrated circuit (I²C) interface while MCP23S17 uses serial peripheral interface (SPI) interface.
- (i) Select **ONE (1)** of the suitable chip either MCP23017 or MCP23S17 for extending the I/O of Arduino system. Give a concrete justification on your selection. (2 marks)
- (ii) Based on the selection in **Q3(b)(i)**, sketch a schematic diagram between I/O expander chip to Arduino controller. (4 marks)
- (iii) To verify the good communication interface, we need to capture and analyze the waveform of data transmission. Analyze the common data transmission protocol for write mode operation of your interface selection in **Q3(b)(i)**. (8 marks)
- Q4** (a) Explain the difference between maximum elapse time (Max_E) and maximum CPU time (Max_CPU) in the temporal scopes of a task. (4 marks)
- (b) Assume a system has three independent tasks A, B, and C as given in **Table Q4**.

Table Q4: Task Specification

Task	CPU resources (ms)	Period (ms)	Deadline (ms)
A	4	10	7
B	2	30	5
C	9	20	20

- (i) If the priority level of Task A > Task B > Task C, draw a task activation diagram for the first 50 ms of system operation. (6 marks)
- (ii) Examine the start delay, elapse time, and completion time for each task. (6 marks)
- (c) Analyze the schedulability of the tasks in the **Table Q4** by using both full tests of rate monotonic schedulability (RMS) and deadline monotonic schedulability (DMS). (16 marks)

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- Q5** An Arduino-based microcontroller system consists of three (3) LEDs that has task exexution as given in **Table Q5**.

Table Q5: Task Execution for LEDs Blinking

Task	LED	Priority	Period	Arduino Pin	Working Area Size
A	LED1	Medium	100 ms	D5	128 bytes
B	LED2	Low	175 ms	D6	64 bytes
C	LED3	High	235 ms	D7	64 bytes

Develop a complete C-code programming to handle all tasks by using FreeRTOS functions library.

(18 marks)

- END OF QUESTIONS -

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