UTHM
Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
(TAKE HOME ASSESSMENT)
SEMESTER II
SESSION 2020/2021

COURSE NAME	:	MICROPROCESSOR AND MICROCONTROLLER
COURSE CODE	:	BEJ30203/BEC30403
PROGRAMME CODE	:	BEJ
EXAMINATION DATE	:	JULY 2021
DURATION	:	4 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS **OPEN BOOK EXAMINATION**

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

Q1 (a) Discuss the importance of the microprocessor in the advancement of the recent technology. Furthermore, give justification on why the microcontroller is preferable for embedded system applications.

(5 marks)

(b) Discuss which microprocessor architecture is suitable for low power application in mobile devices, CISC or RISC?

(4 marks)

(c) Describe the representation of numbers and characters in a microprocessor system.

(4 marks)

(d) Explain the instruction pipeline in the ARM Cortex M3 microcontroller.

(4 marks)

(e) Explain the size of ARM Cortex M3's address bus. How does it relate to the size of the memory?

(3 marks)

(f) Write an assembly program to find maximum value in a set of data from memory location 0x20000000 to 0x2000000F. Illustrate the flowchart of your program.

(12 marks)

Q2 (a) With a suitable example, discuss the importance of the stack in a microprocessor system.

(6 marks)

(b) **Listing Q2(b)** shows the listing file of an assembly program. By referring to **Listing Q2(b)**, answer the following questions:

(i) Give the machine code and size of the instruction MOVT in line 3.

(2 marks)

(ii) Determine the size of the program in **Listing Q2(b)**.

(2 marks)

(iii) Explain why the instruction in line 2 need to be stored at the address 0x00000114 instead of 0x00000111

(4 marks)

(iv) Determine the value of PC when the microprocessor is executing the instruction in line 6.

(2 marks)

(v) Determine the value of PC, LR and SP when the microprocessor is executing the instruction in line 11.

(3 marks)

(vi) Determine the value of PC, LR and SP when the microprocessor is executing the instruction in line 16.

(3 marks)

(vii) Modify the program to add another subroutine named TaskC. TaskC subroutine will be called from subroutine TaskB after the instruction in line 17. The purpose of TaskC subroutine is to move the content of R4 into the memory location 0x10000000.

(6 marks)

```
1:  0x00000110  F8DFD038          LDR     SP, =0x10001000
2:  0x00000114  F2412034  loop    MOVW    R0,#0x1234
3:  0x00000118  F2C56078          MOVT          R0,#0x5678
4:  0x0000011C  F2410010          MOVW    R0,#0x1010
5:  0x00000120  F2CF10F1          MOVT          R0,#0xF1F1
6:  0x00000124  F000F807          BL      TaskA
7:  0x00000128  EB010200          ADD     R2,R1,R0
8:  0x0000012C  EA4F2232          ROR     R2,R2,#8
9:  0x00000130  F000F801          BL      TaskA
10: 0x00000134  E7EE              B       loop
11: 0x00000136  B501      TaskA   PUSH    {R0,LR}
12: 0x00000138  EA400001          ORR     R0,R0,R1
13: 0x0000013C  F000F802          BL      TaskB
14: 0x00000140  BF00              NOP
15: 0x00000142  BD03              POP     {R0,R1,PC}
16: 0x00000144  B402      TaskB   PUSH    {R1}
17: 0x00000146  EA4F1401          LSL     R4,R1,#4
18: 0x0000014A  4770              BX      LR
```

Listing Q2(b)

Q3 **Figure Q3** shows the memory mapped I/O of a LPC1768 microcontroller. It shows that the microcontroller uses the same address space to address both memory and I/O devices. The memory and registers of the I/O devices are mapped to (associated with) address values.

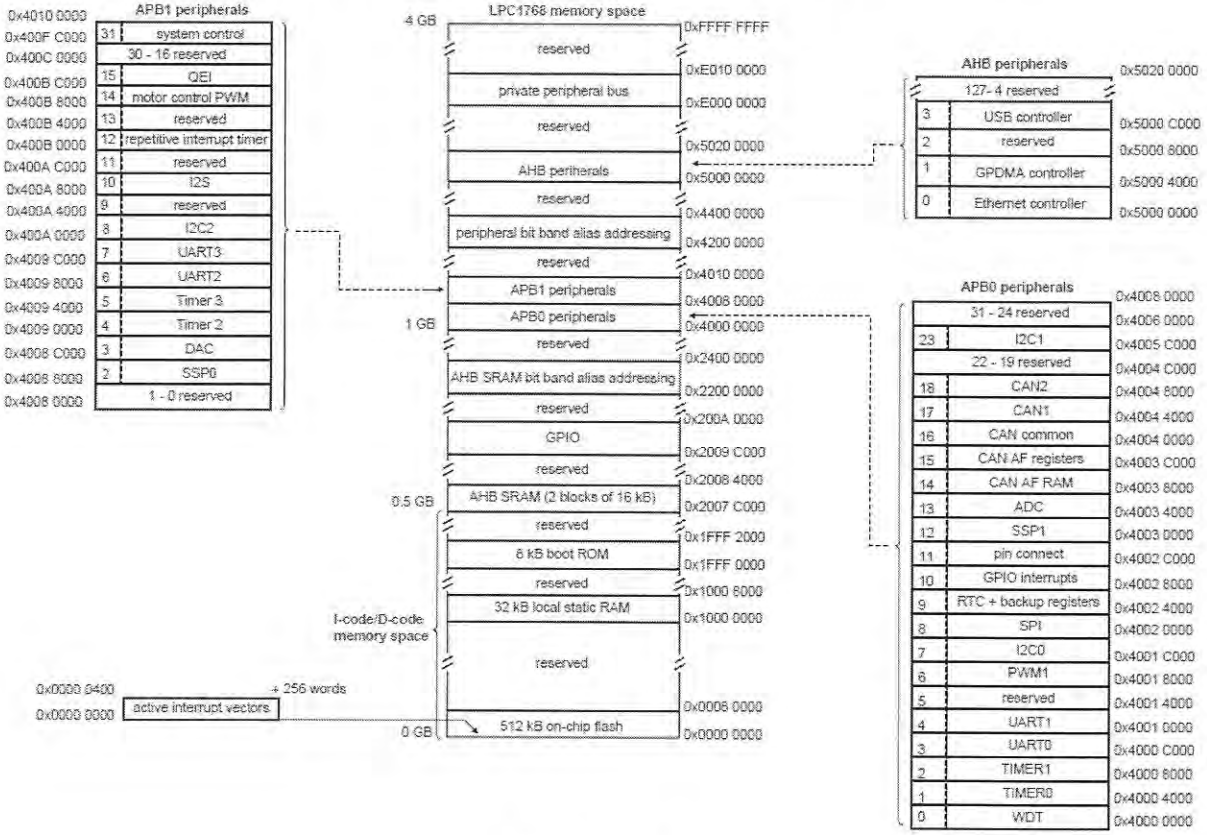

Figure Q3

(a) By referring to the memory map, identify the start and end addresses of the general-purpose input/output (GPIO) and the Analog-to-Digital (ADC) registers.

(2 marks)

(b) For an LPC1768 microcontroller, write a sequence of assembly instruction to set the byte 2 of port 1 as input, while the byte 3 of port 1 as output.

(4 marks)

(c) Discuss the advantage of using the Application Programming Interface (API) in developing microcontroller applications.

(4 marks)

Table Q4

Sensors output	Robot movement
0000	Stop
0001	Turn right
0011	Turn right
0110	Go forward
1100	Turn left
1000	Turn left

(a) The L293D motor driver is used to control the speed of the motors and the speed of the motor is determined by the pulse-width modulation (PWM) signal with different duty cycles that generated by the microcontroller. Write a sequence of codes using the mbed API to create a PWM signal with 20 KHz frequency and 70% duty cycle for both motors.

(3 marks)

(b) Draw a flowchart to devise a program for the robot.

(7 marks)

(c) Write a complete program using the mbed API based on your flowchart in **Q4(b)**.

(10 marks)

(d) If the robot is connected to an analog light sensor on the top of the robot, it is now able to detect the light intensity of the navigation environment. Suppose that, the robot will immediately stop moving when the light level is less than 100 lux. By using the mbed API, write a sequence of codes to setup the ADC and stop the robot as stated by the specification given above. Assume that 100 lux is approximately 2.3 volt analog.

(2 marks)

(e) Now suppose that the light sensor in **Q4(d)** is replaced by the digital sensor that uses the SPI bus to interface with the microcontroller,

(i) With the same specifications as in **Q4(d)**, write a sequence of codes to setup the SPI and stop the robot when the light level is less than 100 lux. Assume that the digital value for 100 lux light intensity is 0x20.

(2 marks)

(ii) By giving suitable examples, discuss the disadvantage of the SPI protocol as compared to I2C protocol.

(2 marks)

(f) If a push button is used to stop the robot manually using interrupt signal,

(i) Write a sequence of codes to setup the interrupt and stop the robot when the button is pressed.

(2 marks)

(ii) Modify your codes in **Q4(f)(i)** such that the robot will stop moving 5 seconds after the button is pressed using the mbed "Timeout" function.

(2 marks)

END OF QUESTIONS