CITY UNIVERSITY OF HONG KONG

Course code & title	:	EE2004 Microcomputer Systems
Session	:	Semester A 2020/21
Time allowed	:	2 hours and 15 minutes

This paper has 6 pages (including this cover page).

Instructions:

Please make sure you follow all instructions from the University, ARRO, and EE. Please note the following:

1. This paper consists of 4 questions. The questions are ALL compulsory. Make sure that you attempt all of them. The total score is 100.
2. This is an **open-book exam.** Students can read the lecture notes and/or other materials available online.
3. You are responsible for receiving the questions on Canvas. Enter your name, student ID number, and the answers in a single MS Word file or a single PDF file. Name the file with your student ID number. Submit the file by e-mail (itklchan@cityu.edu.hk) **before the deadline** of the exam.
4. **Stay on Zoom after the deadline** until the examiner allows you to leave.

Answering this exam paper implies your acknowledgment of the Pledge for following the Rules on Academic Honesty:

"I pledge that the answers in this examination are my own and that I will not seek or obtain an unfair advantage in producing these answers. Specifically,

1. I will not plagiarize (copy without citation) from any source;
2. I will not communicate or attempt to communicate with any other person during the examination; neither will I give or attempt to give assistance to another student taking the examination; and
3. I will use only approved devices (e.g., calculators) and/or approved device models.
4. I understand that any act of academic dishonesty can lead to disciplinary action."

On the first page of your answer sheets, copy the following sentence and sign it: *I pledge to follow the Rules on Academic Honesty and understand that violations may lead to severe penalties. (*Signature) _____ (Date) _____

Contact Information

- Should you have any technical problem during the exam, contact your course leader or invigilator via Zoom private chat, email: itklchan@cityu.edu.hk or by phone call at 3442 7133.
- If you are not able to contact course leader/invigilator, you can reach the department via:
  (a) Departmental hotline at (+852) 3442-7740
  (b) Department Whatsapp phone: 9269-4066
  (c) Department WeChat ID: wxid_lly7yf5fzoj722 or scan the following QR Code

Question 1 (30%)

(a) Given two decimal numbers A = **XY** and B = 87. **X** is the last digit of your student ID number. **Y** is the second last digit of your student ID number.

(i) convert A and B into 2's complement numbers and show the calculation of A – B
[4 marks]

(ii) convert A and B into BCD codes and show the calculation of A + B
[4 marks]

(b) In a given byte-addressable computer with a 21-bit address bus, memory locations 80000h to 1FFFFFh are available for user programs. Each RAM chip is 512 KB.

(i) Draw a diagram to show the connection of CPU, memory chips and address decoder circuit. Assume each memory chip demands active high memory read, memory write and chip select signals.
[10 marks]

(ii) Assume that numbers A and B are stored in memory locations 80000h and 80001h respectively. The computer, assuming A and B are 2's complement numbers, is to calculate A – B. Describe, with the aid of a timing diagram, the process how CPU can get number A.
[6 marks]

(iii) The computer will save the calculation result to memory location 80002h. Describe, with the aid of a timing diagram, the process how CPU can save the subtraction result.
[6 marks]

Question 2 (20%)

(a) Show the calculation of the number of machine cycles for the following program.

			Machine cycle
DELAY:	MOVLW	b'00110100'	1
	MOVWF	R1	1
AGAIN:	MOVLW	99	1
	MOVWF	R2	1
HERE:	NOP		1
	NOP		1
	DECF	R2, F	1
	BNZ	HERE	1 or 2
	DECF	R1, F	1
	BNZ	AGAIN	1 or 2
	RETURN		2

[4 marks]

(b) Calculate the actual time required to execute the program in part (a) if the clock frequency is 4 MHz.

[2 marks]

(c) Modify the program in part (a) such that the time required to execute the modified program is **exactly** 48 msec.

[8 marks]

(d) Write a program to generate a square wave of 50% duty cycle on pin PORTB.3. Each logic state lasts for 48 msec. Assume that the clock frequency is 4 MHz.

[6 marks]

Question 3 (20%)

(a) Write a program to generate the digital values of a cosine wave with angles between 0 and 360 degrees (with 30-degree increments). The full-scale output of the DAC is 10V. Store the cosine function values in a table. Output the cosine wave to PORT D.

[10 marks]

(b) The following program is to convert an analogue voltage to a digital value.

```
        org 0x00
        clrf    TRISB
        goto    Start
Start:  movlw 0x01
        movwf ADCON0, A
        movlw 0x0E
        movwf ADCON1, A
        movlw 0x92
        movwf ADCON2, A
        bsf ADCON0, GO, A
wait_con:
        btfsc ADCON0, DONE, A
        bra wait_con
        movff ADRESH, PRODH
        movff ADRESL, PRODL
        movff PRODH, PORTB
        end
```

(i) Calculate T_{AD}, assuming that the clock frequency is 10 MHz.

[3 marks]

(ii) Calculate T_{ACQ}.

[3 marks]

(iii) If PORTB is connected to 8 LEDs to display the digital value, what is the range of the digital values displayed in the LEDs?

[4 marks]

Question 4 (30%)

Perform arithmetic operation C = A – B, where A, B and C are 8-bit 2's complement numbers. There are four numbers of A stored in locations **X**0h to **X**3h. Similarly, the four numbers of B are stored in locations **Y**0h to **Y**3h. The results of C are saved in locations **Z**0h to **Z**3h. **X** is the last digit of your student ID number plus one. **Y** is the second last digit of your student ID number plus one. If **X** and **Y** are the same, set **Y** equal to the second last digit of your student ID number plus two. **Z** is the third last digit of your student ID number plus one.

(a) Write a program to perform the arithmetic operation using direct addressing mode.

[8 marks]

(b) Write a program to perform the arithmetic operation using register indirect addressing mode with a loop.

[10 marks]

(c) Write a program to perform two alternative arithmetic operations based on the interrupt signal. If the button "P1" is pressed, INT0 (PORTB.0) is activated. Perform arithmetic operation C = A + B. If the button "P2" is pressed, INT1 (PORTB.1) is activated. Perform arithmetic operation C = A – B.

[12 marks]

- END -