PRINCIPLES AND APPLICATIONS OF MICROCONTROLLERS

Final Exam

Rules:

1. This is an open book exam.
2. All questions about the examination should be directed to the instructor or teaching assistants.
3. No communication between the students regarding the examination is allowed.

Honor statement: I have neither given nor received aid on this examination.
(Sign below only if you agree to this statement)

Student ID Number: B09611007

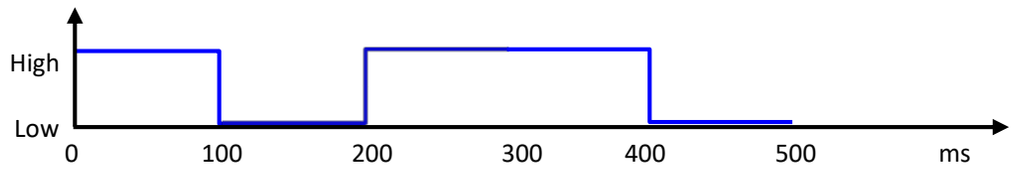
Name: 陳柏霖

Problem A: Short Answers

1. Complete the following table. The numbers are unsigned integers. (4 pt)

Binary	Decimal	Hexadecimal
00111011	59	3B
01010110	86	56
10110101	181	B5
11100010	114	72

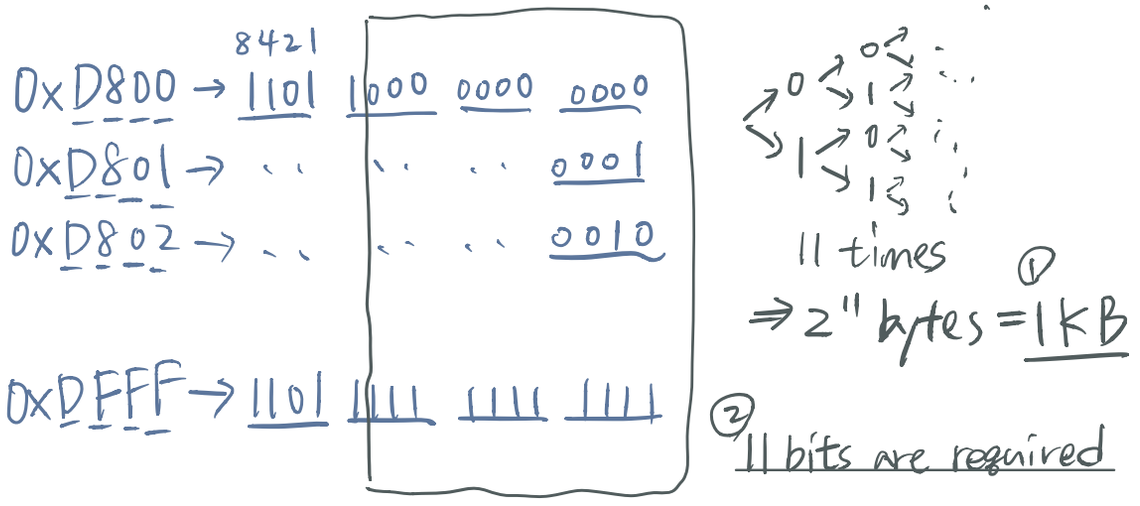
2. Write an Arduino sketch so that Arduino will generate the following output waveform on pin A0. Include any code needed to configure the I/O port properly. You may NOT use the delay function that we have used in the lab assignments. (6%)



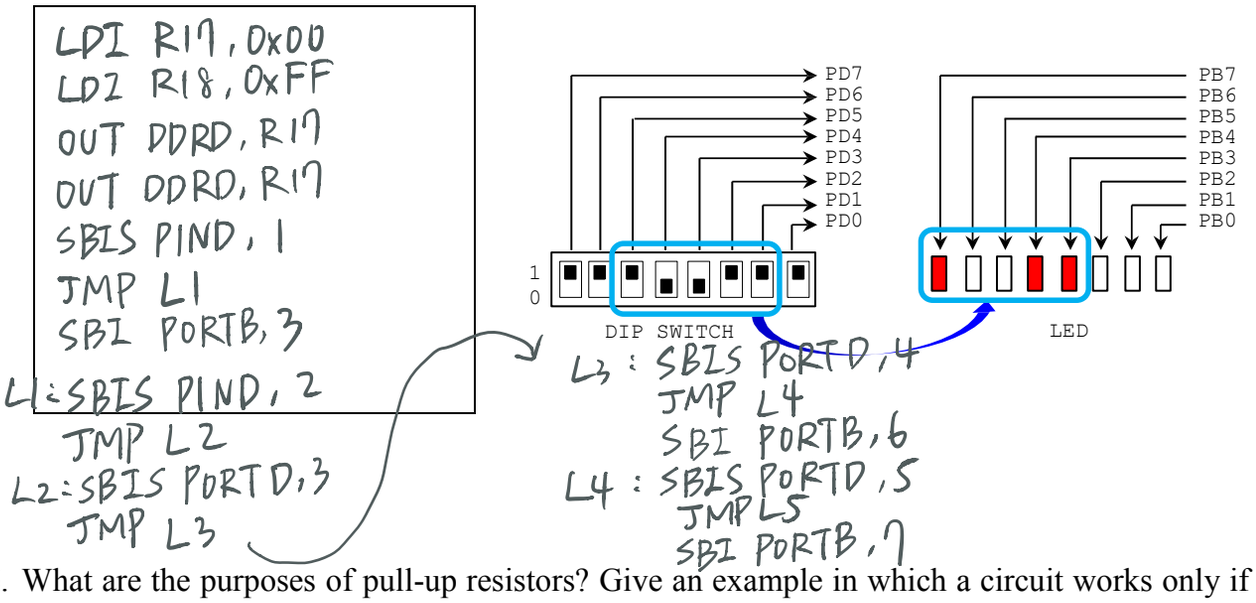

```
int time;

void setup()
{
  pinMode(A0, OUTPUT);
}
void loop()
{
 time = millis();
 if(time>=0 && time<100)
    digitalWrite(A0, HIGH);
 if(time>=100 && time<200)
    digitalWrite(A0, LOW);
 if(time>=200 && time<400)
    digitalWrite(A0, HIGH);
 if(time>=400 && time<500)
    digitalWrite(A0, LOW);
}
```

3. A microprocessor has a 16-bit address line. An SRAM device is connected to the microcontroller. The microcontroller has assigned the addresses 0xD800 to 0xDFFF to this SRAM. What is the size (in KB or MB) of this SRAM? What is the minimum number of bits required to represent the addresses only for this SRAM? (10 pts)

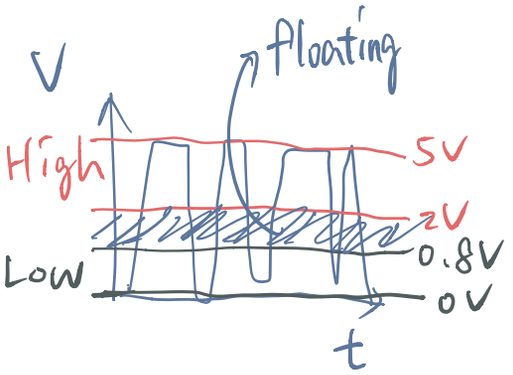


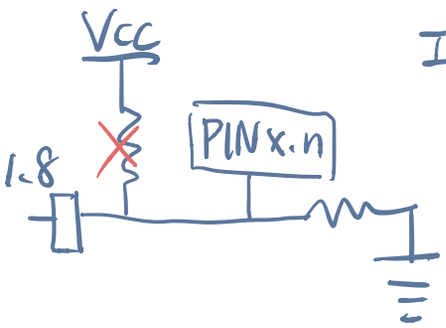
4. Write an assembly program for an AVR ATmega328P so that the state of bits 5 to 1 on the DIP switch (connected to **PORT D**) is displayed only on the bits 7 to 3 on the LEDs (connected to **PORT B**). The figure shows an example: the number 10011 is shown on the five leftmost LEDs, while the other LEDs are off. (10 pts)



5. What are the purposes of pull-up resistors? Give an example in which a circuit works only if there is a pull-up resistor. (10 pts)

Purpose: Bringing the input at expected logic levels, and avoid "floating" situation.





If there is a pull-up resistor
⇒ High
If there is no pull-up resistor
⇒ Floating

6. Convert the following C program to an assembly program. You are free to choose your own general purpose registers. (10 pts)

Assembly	C

LDI R17, 0x0D
LDI R18, 0x0A
L1: SUB R18, R17
BREQ L2
AAD R18, R17
INC R17
JMP L1
L2: ...
	`int i=0;`
	`int j=10;`
	`while (i != j) {`
	`  i++;`
	`}`
	`...`

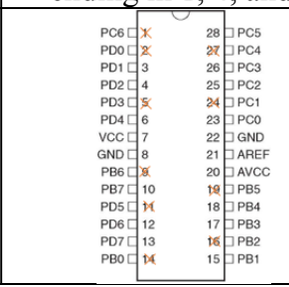
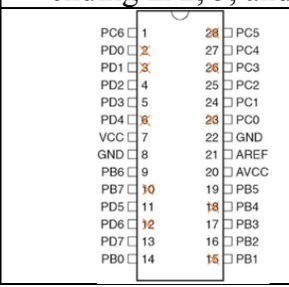
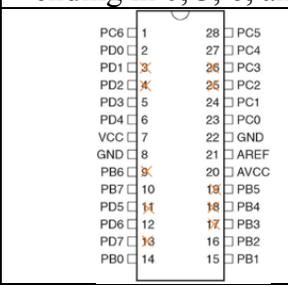
Problem B: Set Questions

Da'Kuo asks the students in his MCU course to build an electronic piano using ATmega328P and assembly. The piano should have seven keys and one buzzer. Da'Kuo separates the students into two groups (see the table below for the details). The students in each group will make the piano play notes in different octaves. Please answer the following questions.

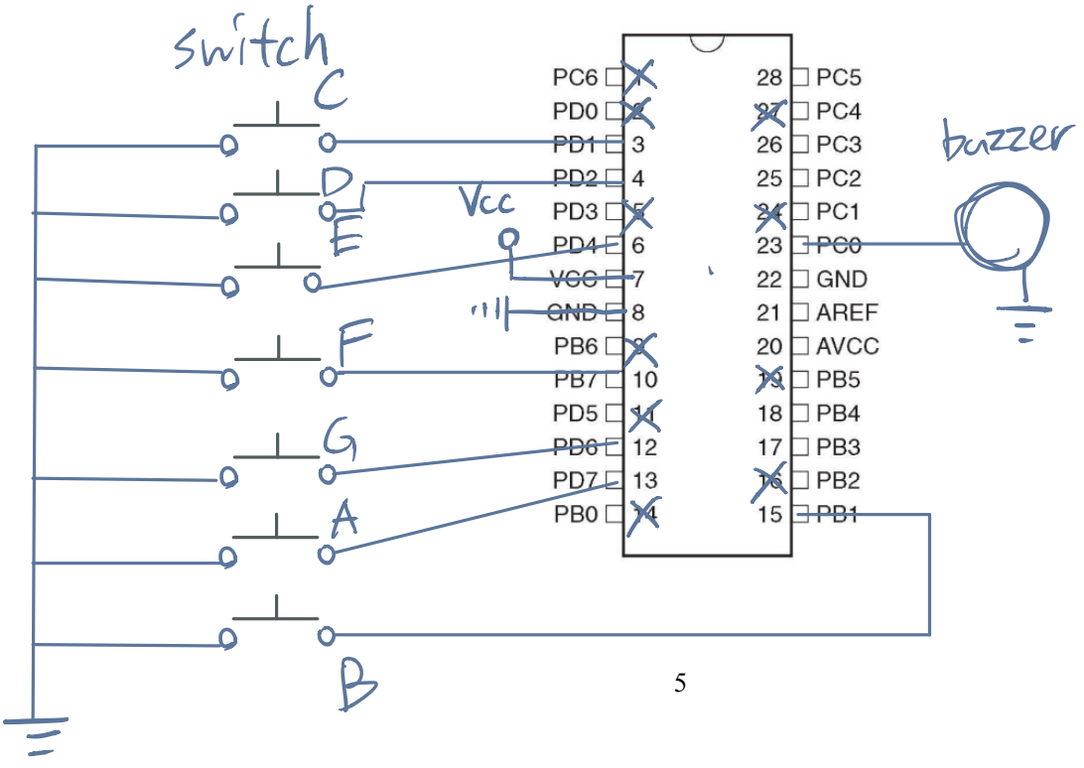
1. Find the note frequencies and complete the following table. (3 pts)

	Students with even ID ending numbers (0, 2, 4, 6, and 8)	Students with odd ID ending numbers (1, 3, 5, 7, and 9)
Octave	C3 = 131 Hz D3 = E3 = F3 = G3 = A3 = B3 =	C5 = 523 Hz D5 = 587Hz E5 = 659Hz F5 = 698Hz G5 = 784Hz A5 = 880Hz B5 = 988Hz

2. As you know, Da' Kuo is a very poor professor. Certain pins of the ATmega328P he has in hand do not work functionally. However, he has no money to replace them. He gives these partially functioned MCU to the students based on the table below.

	Students with IDs ending in 1, 4, and 7	Students with IDs ending in 2, 5, and 8	Students with IDs ending in 0, 3, 6, and 9
MCU			

Fortunately, Da'Kuo has plenty of resistors. Use the resistors as you need. Please design the circuit of your piano using the given ATmega328P. Please put a note on each button so that we can know which frequency it corresponds to. Make your figure professional. (7 pts)



3. With your circuit design, you want to write an assembly program in which you adjust each pin for input or output. Complete the following assembly program. Please be sure to enable pull-up resistors if you intend to use them. (10 pts)

```
LDI R16, 0b00000000
OUT DDRB, R16
LDI R16, 0b11111111
OUT PORTB, R16
LDI R16, 0b11111111
OUT DDRC, R16
```

```
LDI R16, 0b00000000
OUT PORTC, R16
LDI R16, 0b00000000
OUT DDRD, R16
LDI R16, 0b11111111
OUT PORTD, R16
```

4. In the next step, you want to write an assembly program that checks if the buttons are pressed or not. If a button is pressed, your program will call subroutines **`PLAY_[note]`** to play notes. The easier way to check the button status is to use instruction **`SBIC`** or **`SBIS`**, depending on your circuit design. Read the course material "12AVR Assembly 04-Bit manipulating.pdf" on ceiba to understand the usage of **`SBIC`** and **`SBIS`**. Choose one code template (1 or 2) below and complete the assembly. (10 pts)

1

```
AGAIN:  SBIC    _____, __
        CALL    PLAY_C
        SBIC    _____, __
        CALL    PLAY_D
        SBIC    _____, __
        CALL    PLAY_E
        SBIC    _____, __
        CALL    PLAY_F
        SBIC    _____, __
        CALL    PLAY_G
        SBIC    _____, __
        CALL    PLAY_A
        SBIC    _____, __
        CALL    PLAY_B
        JMP     AGAIN
```

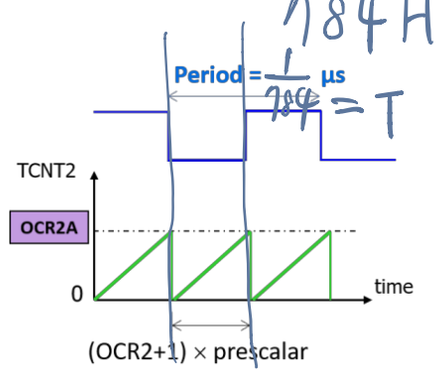
✓ 2

```
AGAIN:  SBIS    PIND, 1
        CALL    PLAY_C
        SBIS    PIND, 2
        CALL    PLAY_D
        SBIS    PIND, 4
        CALL    PLAY_E
        SBIS    PINB, 7
        CALL    PLAY_F
        SBIS    PIND, 6
        CALL    PLAY_G
        SBIS    PIND, 7
        CALL    PLAY_A
        SBIS    PINB, 1
        CALL    PLAY_B
        JMP     AGAIN
```

5. In the last step, you plan to write the subroutine **`PLAY_G`** that plays G3 or G5, depending on your student ID, using Timer 2 in CTC mode. Da' Kuo provides partial program. Please complete the rest. Please calculate the time delay needed using the figure in the right. Note that the system clock runs at 1 Mhz. (20 pts)

```
PLAY_G: LDI   R20, 0b00000001
        OUT   OCR2A, R20
        LDI   R20, 0b00000001
        OUT   TCCR2A, R20
        LDI   R20, 0b10000001
        OUT   TCCR2B, R20
AGAIN:  IN    R20, TIFR2
        SBRS  R20, OCF0A
        JMP   AGAIN
        LDI   R20, 0
        OUT   TCCR2B, R20
        LDI   R20, 1<<OCF0A
        OUT   PORTC, R20
        RET
```

784 Hz



$\frac{1}{784} \times 10^3$ P=1

$T = (OCR2+1) \times \frac{1}{8}$

OCR2 = 0.27

Problem C: Peer evaluation (BONUS; only for those who choose plan A or B) (2 pts)

微控制器組員互評表　第六組

	姓　　名	貢 獻 (%)
1	填表人: 陳柏霖 學號後三碼: 007	60
2	劉耀文	40
3		
	總　　計	100