

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: _____

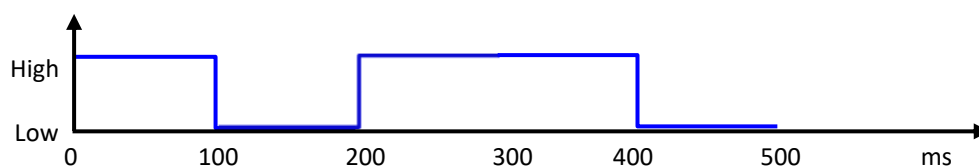
Name: _____

Problem A: Short Answers

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

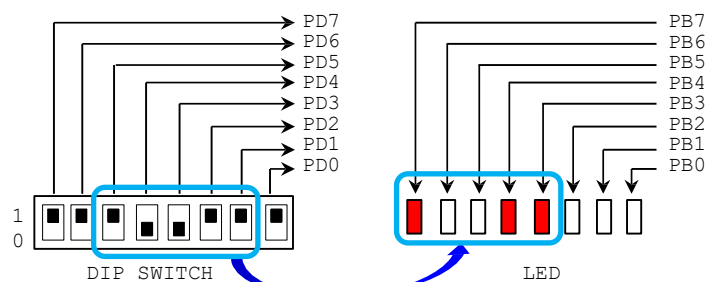
Binary	Decimal	Hexadecimal
00111011		
01010110		
		B5
		72

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%)



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)

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

Assembly	C
	<pre>int i=0; int j=10; while (i != j) { i++; } ...</pre>

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 = E5 = F5 = G5 = A5 = B5 =

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	PC6 <input checked="" type="checkbox"/> 28 <input type="checkbox"/> PC5 PD0 <input checked="" type="checkbox"/> 27 <input type="checkbox"/> PC4 PD1 <input type="checkbox"/> 26 <input type="checkbox"/> PC3 PD2 <input type="checkbox"/> 25 <input type="checkbox"/> PC2 PD3 <input checked="" type="checkbox"/> 24 <input type="checkbox"/> PC1 PD4 <input type="checkbox"/> 23 <input type="checkbox"/> PC0 VCC <input type="checkbox"/> 22 <input type="checkbox"/> GND GND <input type="checkbox"/> 21 <input type="checkbox"/> AREF PB6 <input checked="" type="checkbox"/> 20 <input type="checkbox"/> AVCC PB7 <input type="checkbox"/> 19 <input type="checkbox"/> PB5 PD5 <input checked="" type="checkbox"/> 18 <input type="checkbox"/> PB4 PD6 <input type="checkbox"/> 17 <input type="checkbox"/> PB3 PD7 <input type="checkbox"/> 16 <input type="checkbox"/> PB2 PB0 <input checked="" type="checkbox"/> 15 <input type="checkbox"/> PB1	PC6 <input type="checkbox"/> 1 <input checked="" type="checkbox"/> 28 <input type="checkbox"/> PC5 PD0 <input checked="" type="checkbox"/> 2 <input type="checkbox"/> 27 <input type="checkbox"/> PC4 PD1 <input checked="" type="checkbox"/> 3 <input type="checkbox"/> 26 <input type="checkbox"/> PC3 PD2 <input type="checkbox"/> 4 <input type="checkbox"/> 25 <input type="checkbox"/> PC2 PD3 <input type="checkbox"/> 5 <input type="checkbox"/> 24 <input type="checkbox"/> PC1 PD4 <input checked="" type="checkbox"/> 6 <input type="checkbox"/> 23 <input type="checkbox"/> PC0 VCC <input type="checkbox"/> 7 <input type="checkbox"/> 22 <input type="checkbox"/> GND GND <input type="checkbox"/> 8 <input type="checkbox"/> 21 <input type="checkbox"/> AREF PB6 <input type="checkbox"/> 9 <input type="checkbox"/> 20 <input type="checkbox"/> AVCC PB7 <input checked="" type="checkbox"/> 10 <input type="checkbox"/> 19 <input type="checkbox"/> PB5 PD5 <input type="checkbox"/> 11 <input type="checkbox"/> 18 <input type="checkbox"/> PB4 PD6 <input checked="" type="checkbox"/> 12 <input type="checkbox"/> 17 <input type="checkbox"/> PB3 PD7 <input type="checkbox"/> 13 <input type="checkbox"/> 16 <input type="checkbox"/> PB2 PB0 <input type="checkbox"/> 14 <input checked="" type="checkbox"/> 15 <input type="checkbox"/> PB1	PC6 <input type="checkbox"/> 1 <input type="checkbox"/> 28 <input type="checkbox"/> PC5 PD0 <input type="checkbox"/> 2 <input type="checkbox"/> 27 <input type="checkbox"/> PC4 PD1 <input checked="" type="checkbox"/> 3 <input type="checkbox"/> 26 <input type="checkbox"/> PC3 PD2 <input checked="" type="checkbox"/> 4 <input type="checkbox"/> 25 <input type="checkbox"/> PC2 PD3 <input type="checkbox"/> 5 <input type="checkbox"/> 24 <input type="checkbox"/> PC1 PD4 <input type="checkbox"/> 6 <input type="checkbox"/> 23 <input type="checkbox"/> PC0 VCC <input type="checkbox"/> 7 <input type="checkbox"/> 22 <input type="checkbox"/> GND GND <input type="checkbox"/> 8 <input type="checkbox"/> 21 <input type="checkbox"/> AREF PB6 <input checked="" type="checkbox"/> 9 <input type="checkbox"/> 20 <input type="checkbox"/> AVCC PB7 <input type="checkbox"/> 10 <input type="checkbox"/> 19 <input type="checkbox"/> PB5 PD5 <input type="checkbox"/> 11 <input type="checkbox"/> 18 <input type="checkbox"/> PB4 PD6 <input type="checkbox"/> 12 <input type="checkbox"/> 17 <input type="checkbox"/> PB3 PD7 <input checked="" type="checkbox"/> 13 <input type="checkbox"/> 16 <input type="checkbox"/> PB2 PB0 <input type="checkbox"/> 14 <input type="checkbox"/> 15 <input type="checkbox"/> PB1

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)

PC6 <input type="checkbox"/>	1	28 <input type="checkbox"/>	PC5
PD0 <input type="checkbox"/>	2	27 <input type="checkbox"/>	PC4
PD1 <input type="checkbox"/>	3	26 <input type="checkbox"/>	PC3
PD2 <input type="checkbox"/>	4	25 <input type="checkbox"/>	PC2
PD3 <input type="checkbox"/>	5	24 <input type="checkbox"/>	PC1
PD4 <input type="checkbox"/>	6	23 <input type="checkbox"/>	PC0
VCC <input type="checkbox"/>	7	22 <input type="checkbox"/>	GND
GND <input type="checkbox"/>	8	21 <input type="checkbox"/>	AREF
PB6 <input type="checkbox"/>	9	20 <input type="checkbox"/>	AVCC
PB7 <input type="checkbox"/>	10	19 <input type="checkbox"/>	PB5
PD5 <input type="checkbox"/>	11	18 <input type="checkbox"/>	PB4
PD6 <input type="checkbox"/>	12	17 <input type="checkbox"/>	PB3
PD7 <input type="checkbox"/>	13	16 <input type="checkbox"/>	PB2
PB0 <input type="checkbox"/>	14	15 <input type="checkbox"/>	PB1

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, 0b_____	LDI R16, 0b_____
OUT DDRB, R16	OUT PORTC, R16
LDI R16, 0b_____	LDI R16, 0b_____
OUT PORTB, R16	OUT DDRD, R16
LDI R16, 0b_____	LDI R16, 0b_____
OUT DDRC, R16	OUT PORTD, R16

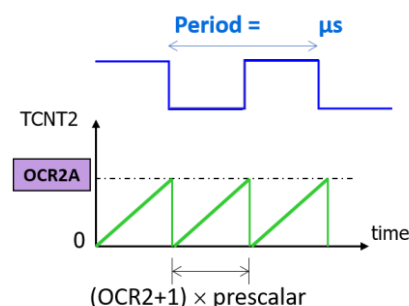
4. In the next step, you want to write an assembly program that checks if the buttons are pressed or not. If a button is pressed, your program will call subroutines **PLAY_**[note] to play notes. The easier way to check the button status is to use instruction **SBIC** or **SBIS**, depending on your circuit 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 _____, _____
	CALL PLAY_C
	SBIS _____, _____
	CALL PLAY_D
	SBIS _____, _____
	CALL PLAY_E
	SBIS _____, _____
	CALL PLAY_F
	SBIS _____, _____
	CALL PLAY_G
	SBIS _____, _____
	CALL PLAY_A
	SBIS _____, _____
	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, 0b_____
	OUT OCR2A, R20
	LDI R20, 0b_____
	OUT TCCR2A, R20
	LDI R20, 0b_____
	OUT TCCR2B, R20
AGAIN:	IN R20, TIFR2
	SBRS R20, _____
	JMP AGAIN
	LDI R20, _____
	OUT TCCR2B, R20
	LDI R20, 1<<OCF0A
	OUT _____, R20
	RET



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_____組

	姓 名	貢 獻 (%)
1	填表人: 學號後三碼:	
2		
3		
	總 計	100