CSS332: Microcontrollers and Applications
Midterm Mock Exam

curated by The Peanuts

Name.....ID.....Section.....Seat No.....

Conditions: Semi-Closed Book

Directions:

1. This exam has 15 pages (including this page).
2. If you finish early, stare at your paper like it's a masterpiece.
3. Write your name clearly, even microcontrollers need proper initialization.
4. Reading the problem is optional but highly recommended.
5. Answers must be written in a structured format. Random noise (scribbles) will not be processed correctly.
6. Going to the toilet may deduct your score, hold it like your grades depend on it.

For solution, click here.

Problem 1

Answer the following questions:

Convert binary 1101 1011 to decimal

Convert decimal 123 to binary and hexadecimal

Convert hexadecimal 0xA7 to binary and decimal

Problem 2

For the addition of 8-bit unsigned numbers: 0xF7 + 0x19, determine:

a) The result in hexadecimal

b) The state of the Carry (C) flag

c) The state of the Zero (Z) flag

d) The state of the Half-carry (H) flag

For the subtraction of signed 8-bit numbers: 0x65 - 0x8A, determine:

a) The result in hexadecimal

b) The state of the Negative (N) flag

c) The state of the Overflow (V) flag

d) Is this result correct from a signed arithmetic perspective? Explain.

Problem 3

Consider the following AVR assembly program:

```
.ORG 0
LDI R16, HIGH(RAMEND)
OUT SPH, R16
LDI R16, LOW(RAMEND)
OUT SPL, R16

LDI R20, 0x5A
LDI R21, 0x3F
LDI R22, 0x81
PUSH R20
PUSH R21
PUSH R22
POP R23
POP R24
POP R25
```

a) What values will be stored in registers R23, R24, and R25 after executing this program?

b) Show the values stored and the stack pointer position each time at *three* points: after all three PUSH instructions, after the first POP instruction, and after all three POP instructions.

c) What would happen if the PUSH and POP instructions were executed without initializing the stack pointer (the first four instructions)? Explain.

Problem 4

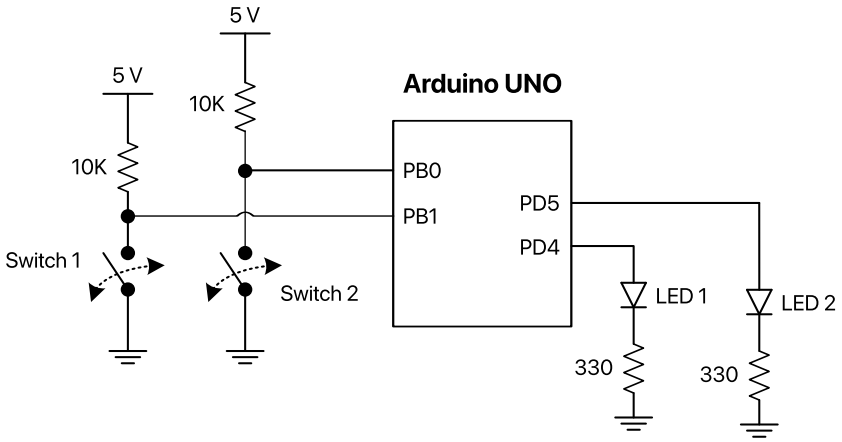
Calculate the total time delay (in milliseconds) for the delay subroutine, assuming the microcontroller is running at 16MHz:

```
DELAY:
    LDI R20, 160
L1:
    LDI R21, 200
L2:
    LDI R22, 250
L3:
    NOP
    NOP
    DEC R22
    BRNE L3
    DEC R21
    BRNE L2
    DEC R20
    BRNE L1
    RET
```

Show your calculations step by step, counting instruction cycles accurately.

Problem 5

The circuit below shows an *Arduino UNO* connected to two switches and two LEDs:



Write a complete assembly program that implements the following functionality:

- Correctly configures the I/O pins (PB0, PB1 as inputs with pull-up resistors; PD4, PD5 as outputs)
- When Switch 1 is pressed (closed state, LOW signal), LED 1 turns ON
- When Switch 1 is not pressed (open state, HIGH signal), LED 1 turns OFF
- Similarly, when Switch 2 is pressed (closed state, LOW signal), LED 2 turns ON
- When Switch 2 is not pressed (open state, HIGH signal), LED 2 turns OFF

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Problem 6

Using the 7-segment display pinout provided in the appendix:

Write a complete assembly program that displays your student ID one digit at a time on a common cathode 7-segment display connected to PORTD.

For example, if your student ID is *6622772422*, the program should display each digit sequentially with an approximately 2-second delay between digits and loop continuously.

Your student ID has 10 digits. If you store these digits in program memory using the `.DB` directive, explain whether or not the padding effect will occur. Would you need to add an extra byte? Why or why not?

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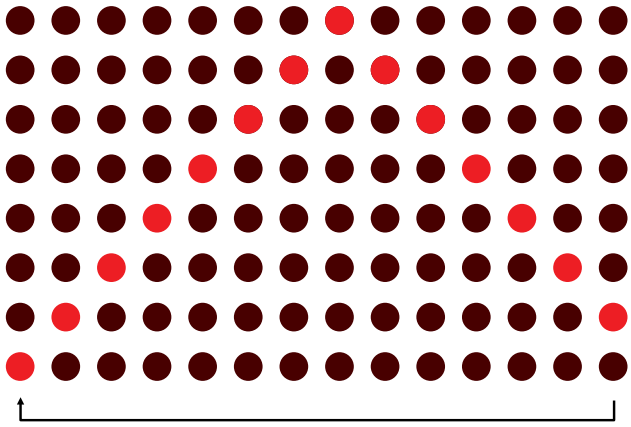
Problem 7

Write a complete assembly program using macros to create a LED sequence on 8 LEDs connected to PORTD (PD0-PD7). The LEDs should light up in a pattern where a single LED appears to move back and forth across the row of LEDs.



Use the following macros in your program:

```
.MACRO DELAY
    LDI  R20, @0
L1: LDI  R21, @1
L2: LDI  R22, @2
L3: NOP
    NOP
    DEC  R22
    BRNE L3
    DEC  R21
    BRNE L2
    DEC  R20
    BRNE L1
.ENDMACRO

.MACRO SETLED
    LDI  R16, @0
    OUT  PORTD, R16
.ENDMACRO
```

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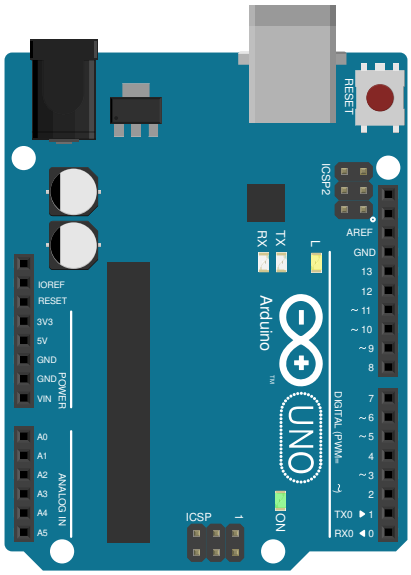
Appendix

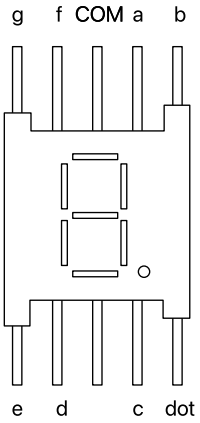
Arduino UNO Pin Layout

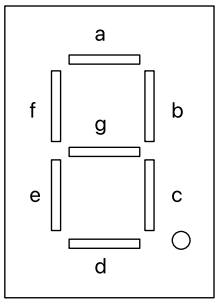
Label	Port
A0	PC0(ADC0)
A1	PC1(ADC1)
A2	PC2(ADC2)
A3	PC3(ADC3)
A4	PC4(ADC4)
A5	PC5(ADC5)



Label	Port
SCL	PC5(ADC5/SCL)
SDA	PC4(ADC4/SDA)
AREF	AREF
GND	GND
13	PB5(SCK)
12	PB4(MISO)
11	PB3(MOSI)
10	PB2(OC1B)
9	PB1(OC1A)
8	PB0
7	PD7
6	PD6
5	PD5
4	PD4
3	PD3(INT1)
2	PD2(INT0)
1	PD1(TXD)
0	PD0(RXD)

7-Segment Display Pinout





Number	g	f	e	d	c	b	a
0	0	1	1	1	1	1	1
1	0	0	0	0	1	1	0
2	1	0	1	1	0	1	1
3	1	0	0	1	1	1	1
4	1	1	0	0	1	1	0
5	1	1	0	1	1	0	1
6	1	1	1	1	1	0	1
7	0	0	0	0	0	1	1
8	1	1	1	1	1	1	1
9	1	1	0	1	1	1	1

Mnemonics	Operands	Description	Operation	Flags	#Clock
Arithmetic and Logic Instructions					
ADD	Rd, Rr	Add two registers	Rd ← Rd + Rr	Z,C,N,V,H	1
ADC	Rd, Rr	Add with carry	Rd ← Rd + Rr + C	Z,C,N,V,H	1
ADIW	Rdl, K	Add immediate to word	Rdh:Rdl ← Rdh:Rdl + K	Z,C,N,V,S	2
SUB	Rd, Rr	Subtract registers	Rd ← Rd - Rr	Z,C,N,V,H	1
SUBI	Rd, K	Subtract immediate	Rd ← Rd - K	Z,C,N,V,H	1
SBC	Rd, Rr	Subtract with carry	Rd ← Rd - Rr - C	Z,C,N,V,H	1
SBCI	Rd, K	Subtract with carry imm.	Rd ← Rd - K - C	Z,C,N,V,H	1
SBIW	Rdl, K	Subtract imm. from word	Rdh:Rdl ← Rdh:Rdl - K	Z,C,N,V,S	2
AND	Rd, Rr	Logical AND	Rd ← Rd × Rr	Z,N,V	1
ANDI	Rd, K	AND with immediate	Rd ← Rd × K	Z,N,V	1
OR	Rd, Rr	Logical OR	Rd ← Rd ∨ Rr	Z,N,V	1
ORI	Rd, K	OR with immediate	Rd ← Rd ∨ K	Z,N,V	1
EOR	Rd, Rr	Exclusive OR	Rd ← Rd ⊕ Rr	Z,N,V	1
COM	Rd	One's complement	Rd ← 0xFF - Rd	Z,C,N,V	1
NEG	Rd	Two's complement	Rd ← 0x00 - Rd	Z,C,N,V,H	1
INC	Rd	Increment	Rd ← Rd + 1	Z,N,V	1
DEC	Rd	Decrement	Rd ← Rd - 1	Z,N,V	1
Branch Instructions					
RJMP	k	Relative jump	PC ← PC + k + 1	None	2
JMP	k	Direct jump	PC ← k	None	3
RCALL	k	Relative call	PC ← PC + k + 1	None	3
CALL	k	Direct call	PC ← k	None	4
RET		Return from subroutine	PC ← STACK	None	4