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EE109: Intro to Embedded Systems
Fall 2025 – Quiz 1
09/30/25, 7PM – 8:15PM

[Complete all the information in the box below.]

Name:____Solutions_____

Student ID: _____

Email: _____@usc.edu

Lecture section (Circle One):

	Redekopp	Puvvada	Weber
	11 a.m.	12:30 p.m.	2 p.m.

- **Erase and fill in checkboxes completely (e.g. ❑ => ■)**
- **All work MUST be on the FRONT (not back) of EXAM PAGES.**
- **No Scratch work will be graded or viewed.**
- **Do NOT write in the upper-right corner of the page with the QR code.**

Ques.	Your score	Max score	Recommended Time
1		8	8 min.
2		10	10 min.
3		12	15 min.
4		6	7 min.
5		14	35 min.
Total		50	75 min.

Calculators are ONLY allowed on Question 3 – Analog/Resistive Circuits.

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1. **(8 pts.) Number Systems**

1.1. Convert **10111001** binary to unsigned **decimal**: ___**128+32+16+8+1=185**___

1.2. Convert **105 decimal** to **(unsigned) binary** (use exactly 8 bits): 0b____**0110 1001**_____

64+32+8+1 = 105

1.3. Convert **110.01011101** unsigned **binary** to **hexadecimal**:

❑ **C.B5** ❑ **5.BA** ❑ **6.BA** ❑ **C.5B** ■ **6.5D** ❑ **None of these**

Suppose, **Club** A has **9** members, **club** B has **5** members, and **club** C has **2** members

1.4. If we combined the members of ALL 3 clubs and assigned each one a unique binary number, we would need to use a minimum of _____ bits.

❑ **3 bits** ■ **4 bits** ❑ **5 bits** ❑ **6 bits** ❑ **64 bits** ❑ **None of these**

1.5. If we represented each member with two values: a unique **club** ID and a unique **member** ID (unique within that club), **club A's** members would need use a ___ (❑ **1** / ■ **2** / ❑ **3**) bit club ID and a ___ (❑ **2** / ❑ **3** / ■ **4** / ❑ **5** / ❑ **9**) bit member ID.

1.6. The value 2^{18} is approximately: ❑ **128K** ■ **256K** ❑ **256M** ❑ **13K** ❑ **23M** ❑ **512K**

2. (**10 pts**.) **Bit Manipulations**. Complete the following **single-line** statements to perform the desired operation stated in the line(s) above the blanks. Assume a standard bit numbering (**bit 7** is the MSB, **bit 0** is the LSB = Least Significant Bit). You may NOT change the structure or code given.

2.1. Turn off (clear to 0), bit **4** of PORTD without affecting other bits of PORTD.

```
PORTD _&= ~(1 << 4) _; // or 0xEF or ~(0x10) or 0b11101111
```

2.2. Turn on (set to 1), bit **6** and **1** of DDRB without affecting other bits of DDRB.

```
DDRB _|= (1 << 6)|(1<<1) _; // or 0x42 or or 0b01000010
```

2.3. Assume bit **7, 5, and 2** of Group C are already configured to be inputs. By accessing a register ONLY once, complete the if statement to be true ONLY if **bit 7 and 5 are logic '1' (high voltage) and bit 2 is logic '0' (low voltage)**.

```
if(_(PINC & 0xa4)___     _==_    0x_a0____) {…};
                      (choose == or !=)
(PINC & ((1<<7)|(1<<5)|(1<<2)))
```

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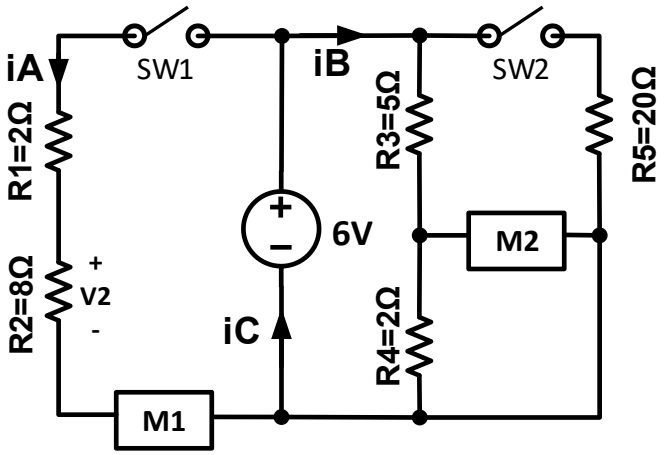
3. **(12 pts.) Resistive Circuits.** Examine the circuit below where M1 and M2 are "mystery" (unknown) devices. For **ALL problems**, **assume all switches are OPEN**, and we will only specify which are **closed** in the problem. ***A calculator may be used for this problem only.***

All problems are worth **1.5 pts** unless otherwise specified.

Partial credit will not be given.



3.1. If both switches are **CLOSED**, which of the following are true:

- ❑ **iA = iB + iC**
- ❑ **iB = iA + iC**
- ■ **iC = iA + iB**
- ❑ **None of these**

3.2. Suppose it is not known whether **SW1** and **SW2** are open or closed nor what the mystery devices, M1 and M2, are. We can say that **iB** ____ **(is / may be / is not**) zero (0) amps.

❑ **is** ❑ **may be** ■ **is not**

3.3. If **SW1** is **closed,** and **M1** is a **wire** then **iA** = __**0.6**___Amps

(Ohm's law I=V/R => I = 6 / (2+8) = 6/10.

3.4. If **SW1** is **closed,** and **M1** is a **2Ω resistor** then **V2** = ____**4**____ Volts

Voltage Divider: V2 = [8 / (2 + 8 + 2)] * 6 = [8/12] * 6 = 4.

3.5. If **SW1** is **closed,** and **M1** is an **OPEN circuit**, then **V2** = __**0**_____ Volts

(Ohm's law I=V/R => Since I=0, V= 0. Or

Voltage Divider: V2 = [8 / (2 + 8 + inf)] * 6 = [8/inf] * 6 = 0

3.6. If **SW2** is **closed,** and **M2** is an **OPEN circuit**, then **R3** is in parallel with **R5**. ❑ **T** ■ **F**

3.7. If **SW2** is **closed,** and **M2** is a **wire**, then **R3** is in series with **R4**. ❑ **T** ■ **F**

3.8. If **SW2** is **closed,** and **M2** is a **wire**, then the equivalent resistance of **R3, R4, R5, and M2** (i.e. the right half of the circuit) is:

❑ **1.85 ohms** ■ **4 ohms** ❑ **5.19 ohms** ❑ **6 ohms** ❑ **27 ohms** ❑ **None of these**

If M2 is a wire, R4 is in parallel with a wire. The Req=0 (i.e. R4 goes away. So now R3 is just in parallel with R5. So Req = 20*5 / (20+5) = 100/25 = 4.

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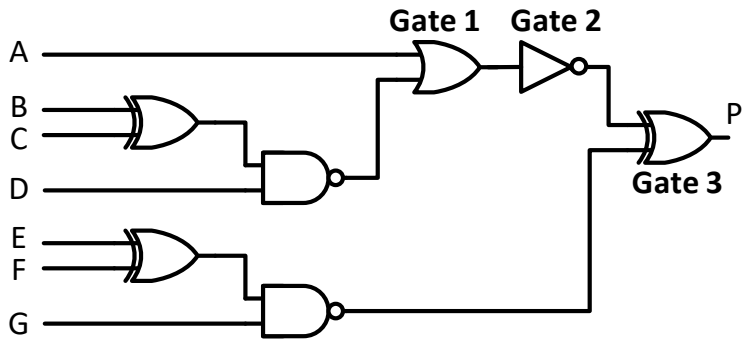
4. (6 pts.) **Logic Circuits**: Consider the circuit shown below and reproduced at the bottom for markup.



Questions:

4.1. An equivalent circuit can be formed by replacing **gate 1 and gate 2** with a single: _____ gate.
■ **NOR** ❑ **NAND** ❑ **XOR** ❑ **XNOR**

4.2. Assuming **gate 1 and gate 2** were replaced with your answer from part 1, how many **levels of logic** would the resulting circuit be?
❑ **2** ❑ **3** ■ **4** ❑ **5** ❑ **6** ❑ **None of these**

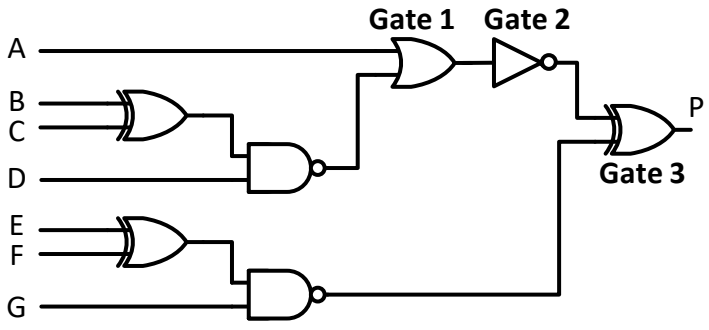
4.3. Given {A,B,C,D,E,F,G} = {0,1,0,1,0,0,1}, the output P is _____. ■ **0** ❑ **1**

4.4. Given {A,B,C,D,E,F,G} = {0,0,1,0,1,1,1}, the output P is _____. ❑ **0** ■ **1**

4.5. If **A=1**, the values of **B, C, & D** have **NO EFFECT** on the output **P**. ■ **True** ❑ **False**

4.6. It is given that **D=0** and **G=0** (but **NO** other inputs are known), we can say that **P=____?**
❑ **0** ■ **1** ❑ **Unable to be determined**

Repeated drawings for your own scratch work and annotation (will not be graded):



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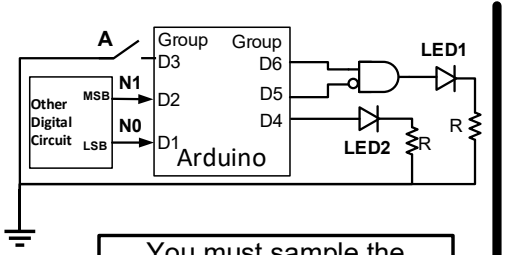
5. (14 pts.) **READ THE ENTIRE PAGE before solving.** Using the Arduino circuit below (exactly as drawn) with three inputs: **1 button (A) on group D, bit 3, and a 2-bit digital input: (N1 and N0) produced by another digital circuit (not buttons/switches) on group D, bits 2 and 1, respectively**. You should control **LED1, which is connected to an INVERTER and AND gate (shown in the diagram) that connects to Arduino outputs group D, bit 6 and 5, and LED2 on group D, bit 4. <u>Complete</u>** the code on the following page that implements the behavior described below.

   All buttons must be sampled every **50 ms**. You must implement the different simultaneous behaviors for **LED1** and **LED2** as described in the diagram below.



You must sample the buttons every 50 ms

LED1 Behavior

LED1 should be :

- **ON** when **A is pressed and N1,N0 = 3 dec**.
- **OFF**, otherwise.

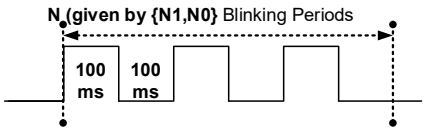
LED2 Behavior

When **A** is **pressed:**

- Sample {N1,N0} which acts as a 2-bit binary number, N, and then Blink LED2 **on** for **100** ms and **off** for **100** ms for the number of periods given by N. So if {N1,N0} = **10**, blink the LED **2** times.

When **A** is **NOT pressed:**

- LED2 should be **OFF**.



For LED2, the implementation on the next page samples the inputs to produce a variable `n` that corresponds to the value (3, 2, 1, or 0) of the two bits: **N1** and **N0**. It then derives a `count` variable to track time and produce the blinking sequence. Complete the code on the next page by filling in the appropriate blanks.

Important Requirements and Reminders

- The **bit positions and some MASKS for the inputs and outputs are defined at the start of the program**. These can be used wherever needed in the program.
- The program must **check/sample the button inputs every <u>50 ms</u>**.
- You may **NOT** change the code structure given, but may **ONLY** fill in the given blanks.
- You need not worry about debouncing the button presses.
- **Recall**: All DDR and PORT register bits initialize to 0 on startup.

Complete your code on the page below!

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```
1  #include <avr/io.h>
2  #include <util/delay.h>       // allows for _delay_ms() function
3  const int A=3, N1=2, N0=1, LED2=4;
4  int main() {
5    unsigned int n = 0, count = 0;
6    unsigned char IMASK1 = 0x0e, IMASK2 = 0x08, IMASK3 = 0x06; // Masks to use below
7    unsigned char OMASK4 = 0x70, OMASK5 = 0x60, OMASK6 = 0x10; // Masks to use below
8    // Add the appropriate initialization (at most 3 lines)
9    DDRD _|=___  (OMASK4__);   // Add an operator and choose between OMASK 4, 5, or 6
10
11   _PORTD_ |=  (IMASK2);  // Fill in the register & choose between IMASK 1, 2, or 3
12   while(1) {
13     // LED1 logic
14
15     if( (_PIND _ & (IMASK1___)) == _0x06 / ((1 << N1) | ( 1 << N0))_) {
16       // To do: Choose a register, IMASK 1, 2 or 3 & a correct comparison constant
17       PORTD |= (1 << 6);
18     } else {
19       PORTD _&= ~(1 << 6) / 0xbf / ~0x40___;  // Complete the statement
20     }
21
22     // LED2 logic
23
24     if( (__PIND_ & (IMASK2___)) == _0_) {
25       // To do: Choose a register, IMASK 1, 2 or 3 & a correct comparison constant
26       n = (PIND & (IMASK_3_)) >> _1__; // To do: Sample and produce number, n
27       count = _4*n_;              // To do: Write an expression in terms of n
28     }
29
30     if( count > 0 ) {
31       count--;
32       if(count % _4__ == 3) {         // Fill in the appropriate expression
33         PORTD |= _(1<<LED2) / (1 << 4) / 0x10__;   // Fill in an appropriate mask
34       } else if(count % _4__ == 1) {
35         PORTD _&= 0xef / ~(1<<4) / ~(1<<LED2) / ~0x10_;   // Complete the statement
36       }
37     }
38     _delay_ms(50);            // Cannot be changed
39   } /* end while */
40   return 0;
41 } /* end main */
42
```

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SCRATCH PAPER. NO WORK ON THIS WILL BE GRADED.