

0. Name (2 pts):

AME 3623: Embedded Real-Time Systems
Midterm Exam
March 8, 2012

General instructions:

- This examination booklet has 9 pages.
- Write your name at the top of the page and sign your name below.
- The exam is closed book, closed notes, and closed electronic device. The exception is that you may have one page of your own notes.
- The exam is worth a total of 100 points (and 10% of your final grade).
- Explain your answers clearly and concisely. Do not write long essays (even if there is a lot of open space on the page). A question worth 5 points is only worth an answer that is at most 2 sentences.
- You have 1.25 hours to complete the exam. Be a smart test taker: if you get stuck on one problem go on to the next. Don't waste your time giving details that the question does not request. Points will be taken off for answers containing excessive or extraneous information.
- Show your work. Partial credit is possible, but only if you show intermediate steps.

Topic	Max	Grade
Name	2	
Number Systems	25	
Analog Processing	25	
Microcontrollers	20	
Digital Input/Output	30	
Total	100	

On my honor, I affirm that I have neither given nor received inappropriate aid in the completion of this exam.

Signature: _____

Date: _____

1. **Number Systems**

(25 pts)

- (a) (5 pts) What is the sum of binary numbers 111011100 and 10000100? Show your work.
- (b) (5 pts) What is the decimal equivalent of the above result?
- (c) (5 pts) Consider the following number: $0x8F$. If we interpret this as a signed 8-bit integer, what is the decimal equivalent? Show your work.
- (d) (5 pts) Consider the following number: $0x813$. If we interpret this as a signed 16-bit integer, what is the decimal equivalent? Show your work.

(e) (5 pts) Consider the following code:

```
uint8_t x = 0x11;  
uint8_t y;
```

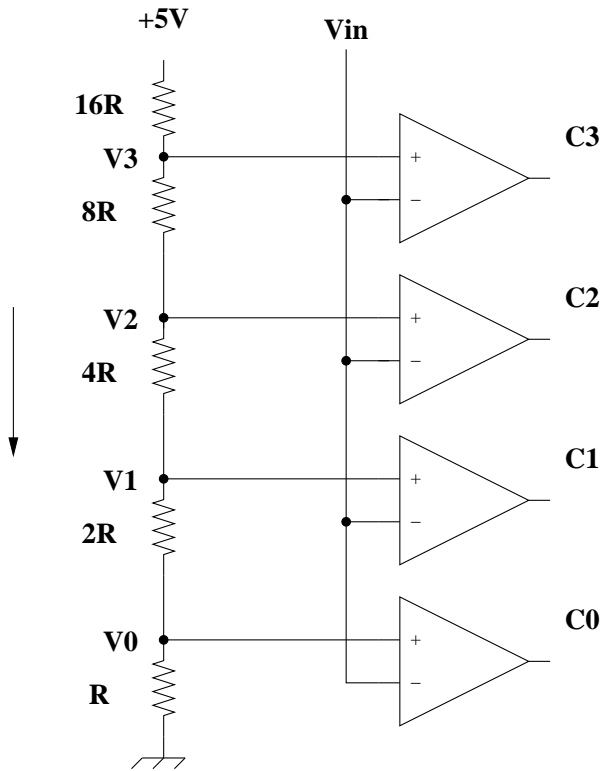
```
y = x << 4
```

What is the value of y in hexadecimal?

2. Analog Processing

(25 pts)

Given the following circuit:



Assume that R is known and that the analog comparators are powered with +5V.

- (a) (5 pts) What are the equations that are always true for the left-hand-side of the circuit?

(b) (10 pts) Solve for $V_0.. V_3$ (simplified fractions are sufficient).

(c) (10 pts) Sketch $C_0 \dots C_3$ as a function of V_{in}

3. Microcontrollers

(20 pts)

(a) (8 pts) Briefly explain the function of the instruction decoder.

(b) (5 pts) True or False, and briefly explain: the ALU receives values for the addition operation from RAM.

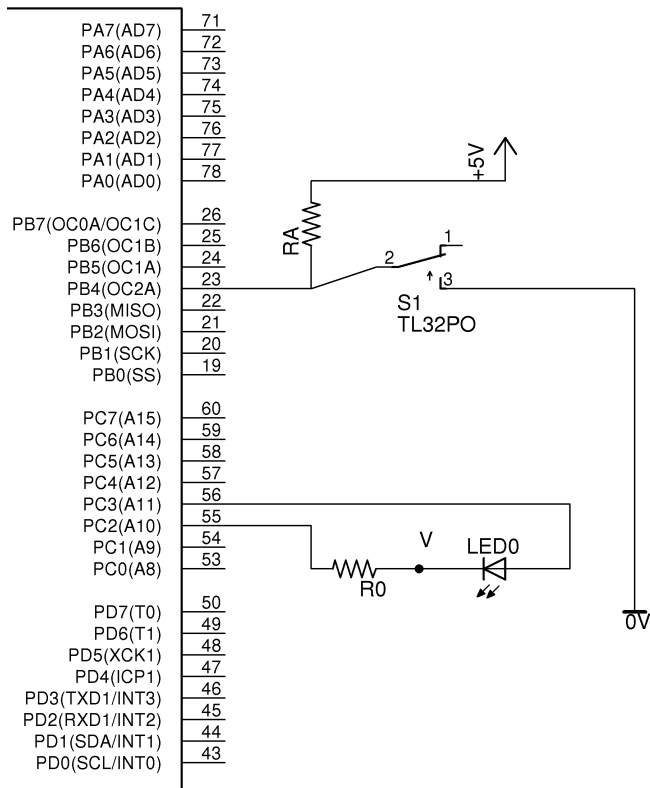
(c) (7 pts) Briefly explain the role of the status register in this line of code:

```
if (x == 5) { ... }
```

4. Digital Input/Output

(30 pts)

Consider the following circuit diagram:



Assume that $DDRC = 0xC$, $V_f = 3V$ and $R_0 = 100\Omega$.

- (a) (5 pts) What equations are always true for the LED0 subcircuit? (Assume that positive currents for I_D and I_{R_0} flow from right to left).
- (b) (5 pts) Assume that $PC[3, 2] = 1, 0$. What are V and I_D ?

Consider the following code:

```
int main (void)
{
    DDRC = 0xC;
    PORTC = 0;
    uint8_t val1 = 0;
    uint8_t val2 = 4;

    while(1) {
        if (PINB & 0x10) {
            PORTC = (PORTC & ~0xC) | (val1 << 2); // Note bit-wise not

            ++val1;
            if (val1 == 4) val1 = 0;

            delay_ms(100);
        } else {
            PORTC = (PORTC & ~0xC) | val2; // Note bit-wise not

            val2 ^= 0xC;

            delay_ms(50);
        };
    };
}
```

(c) (10 pts) Explain what happens when the switch is in a “closed” state.

(d) (10 pts) Explain what happens when the switch is in a “open” state.