0. Name (2 pts):

AME 3623: Embedded Real-Time Systems
Midterm Exam
March 10, 2011

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	
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 binary equivalent of $0x2EF$? Show your work.

    (b) (5 pts) What is the hexadecimal equivalent of decimal 272? Show your work.

    (c) (5 pts) What is the binary equivalent of decimal number 78? Show your work.

(d) (5 pts) Consider the following bit pattern: 11011011. If we interpret this as a signed 8-bit integer (i.e., two's complement), what is the decimal equivalent? Show your work.

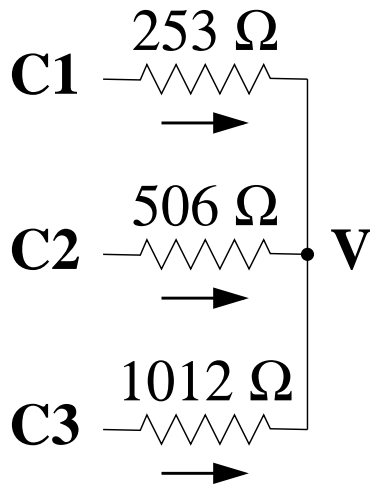(e) (5 pts) Consider the following code:

```
uint16_t  x;
uint16_t  y;

y = (x << 2) + x
```

What mathematical operation is being performed? Give the simplest equation in terms of integer operators $(*, +, /, -)$ and the variables x and y.

2. Analog Processing (25 pts)

Given the following circuit:

$C1$, $C2$ and $C3$ are digital output pins from a microcontroller. Assume that $Ci \in \{0, 1\}$ and are all known.

(a) (5 pts) What are the four fundamental equations that relate the key variables together? Indicate which variables are unknown.

(b) (10 pts) Solve for V as a function of $C1$, $C2$, $C3$.

(c) (10 pts) Which bit pattern yields the voltage at V closest to 2 Volts? (the bit pattern can yield a voltage that is either above or below, but it must be the closest)

3. **Microcontrollers** (20 pts)

(a) (5 pts) True or False, and briefly explain. Both RAM and general purpose registers are used to store program variables.

(b) (5 pts) Briefly explain the function of the *program counter*.

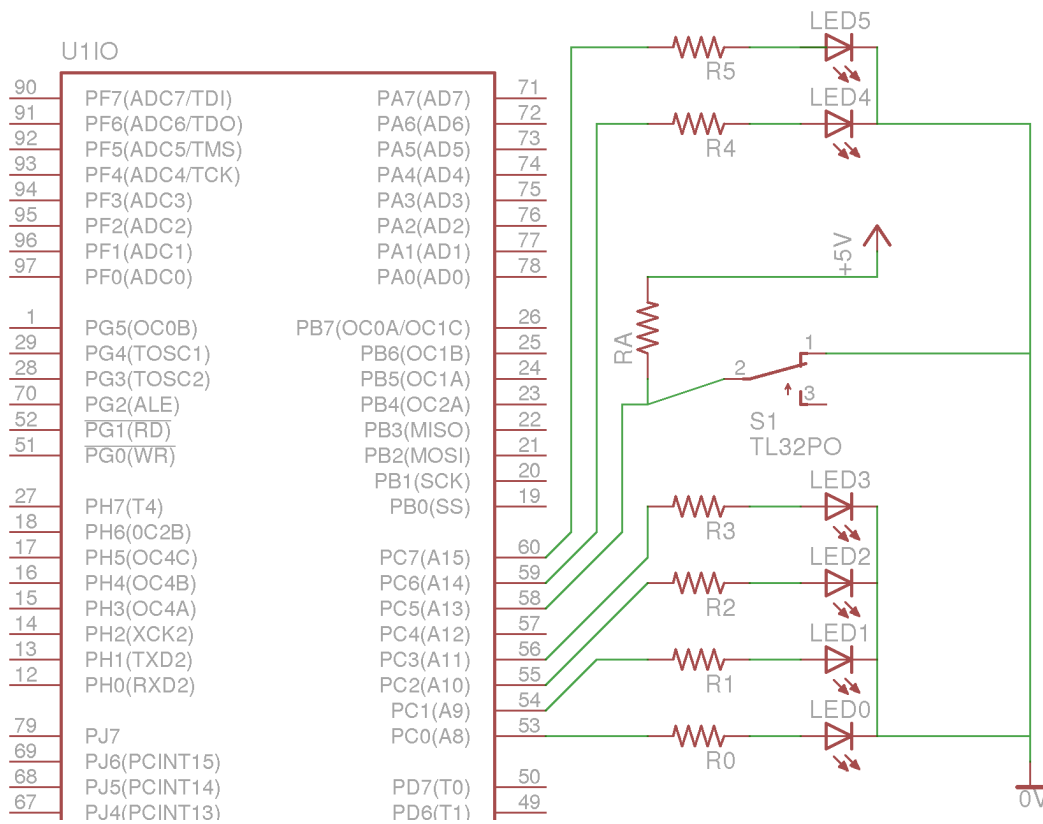(c) (5 pts) Does the following C code result in a read or a write operation to the RAM?

```
uint8_t x = 5;
```

(d) (5 pts) True or False and briefly explain: A ROM device allows data to be written to a requested address.

4. Input/Output (30 pts)

Consider the following circuit diagram:

And consider the following code:

```c
int main (void)
{
  DDRC = 0xCF;
  PORTC = 0;

  while(1) {
    if(PINC & 0x20) {
      PORTC ^= 0x3;
      delay_ms(100);
    }else{
      PORTC ^= 0x98;
      delay_ms(50);
    };
  };
}
```

(a) (10 pts) Explain what happens when the switch is in an "open" state.

(b) (10 pts) Explain what happens when the switch is in a "closed" state.

(c) (10 pts) Assume the same circuit. The following program is intended to produce a 100 Hz, 20% duty cycle signal on LED 4. However, there are several bugs in the code. Provide fixes for each.

```c
int main (void)
{
   DDRC = 0x4;
   PORTC = 0;

   while (1) {
      PORTC &= 0x4;
      delay_ms (2);
      PORTC |= ~0x4;
      delay_ms (10);
   };
}
```