0. Name (2 pts):

AME 3623: Embedded Real-Time Systems

Midterm Exam

March 11, 2010

General instructions:

- This examination booklet has 12 pages.
- Write your name at the top of the page and to 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.

Problem	Topic	Max	Grade
0	Name	2	
1	Number Systems	10	
2	Sequential Logic	30	
3	Memory	20	
4	Microcontrollers	25	
5	Serial Communication	15	
Total			

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

Signature: _____

Date: _____

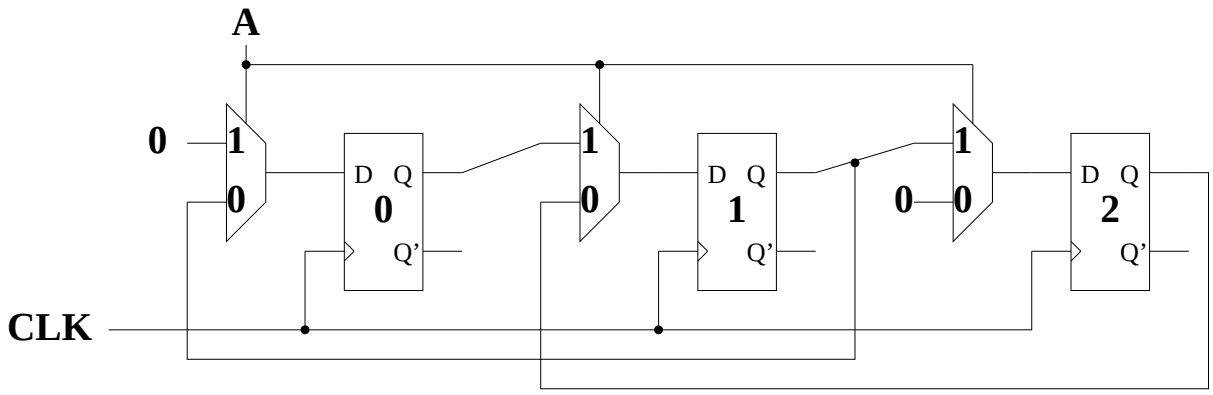
1. **Number Systems** (10 pts)

(a) (5 pts) What is the binary equivalent of $0xC3A$? Show your work.

(b) (5 pts) What is the hexadecimal equivalent of decimal 429? Show your work.

2. **Sequential Logic** (30 pts)

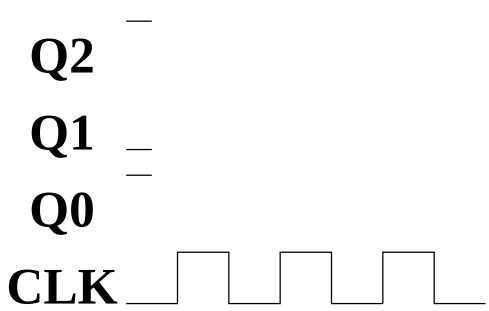
Given the following circuit:



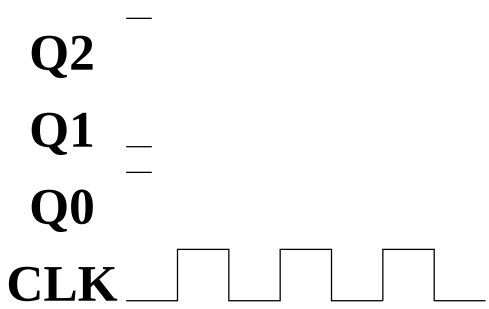
(a) (15 pts) Fill in the following truth table (the Dx and "value D" columns). Note that "value Q" is the decimal value that results from interpreting $Q2, Q1, Q0$ as a binary number. refer to the data input to the flip-flops. "Value D" is the decimal value that results from interpreting $D2, D1, D0$ as a binary number.

A	Q2	Q1	Q0	value Q	D2	D1	D0	value D
0	0	0	0	0				
0	0	0	1	1				
0	0	1	0	2				
0	0	1	1	3				
0	1	0	0	4				
0	1	0	1	5				
0	1	1	0	6				
0	1	1	1	7				
1	0	0	0	0				
1	0	0	1	1				
1	0	1	0	2				
1	0	1	1	3				
1	1	0	0	4				
1	1	0	1	5				
1	1	1	0	6				
1	1	1	1	7				

(b) (5 pts) Assume that the initial state is $Q2, Q1, Q0 = 101$ and that $A = 0$. Fill in the following timing diagram:



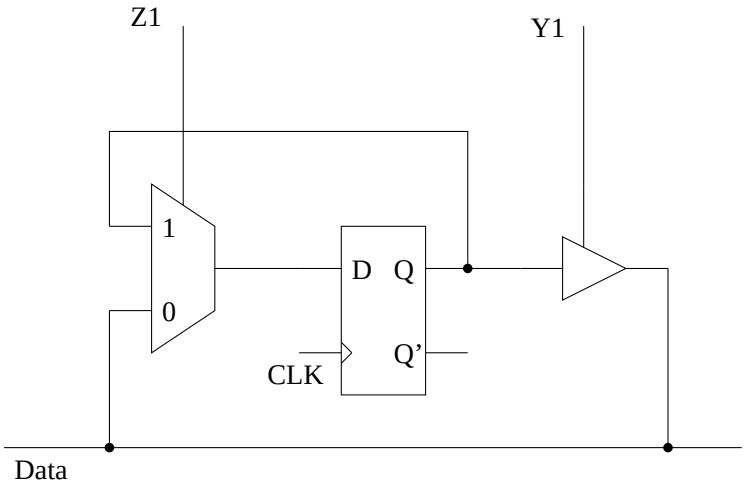
(c) (5 pts) Assume the same initial state and that $A = 1$. Fill in the following timing diagram:



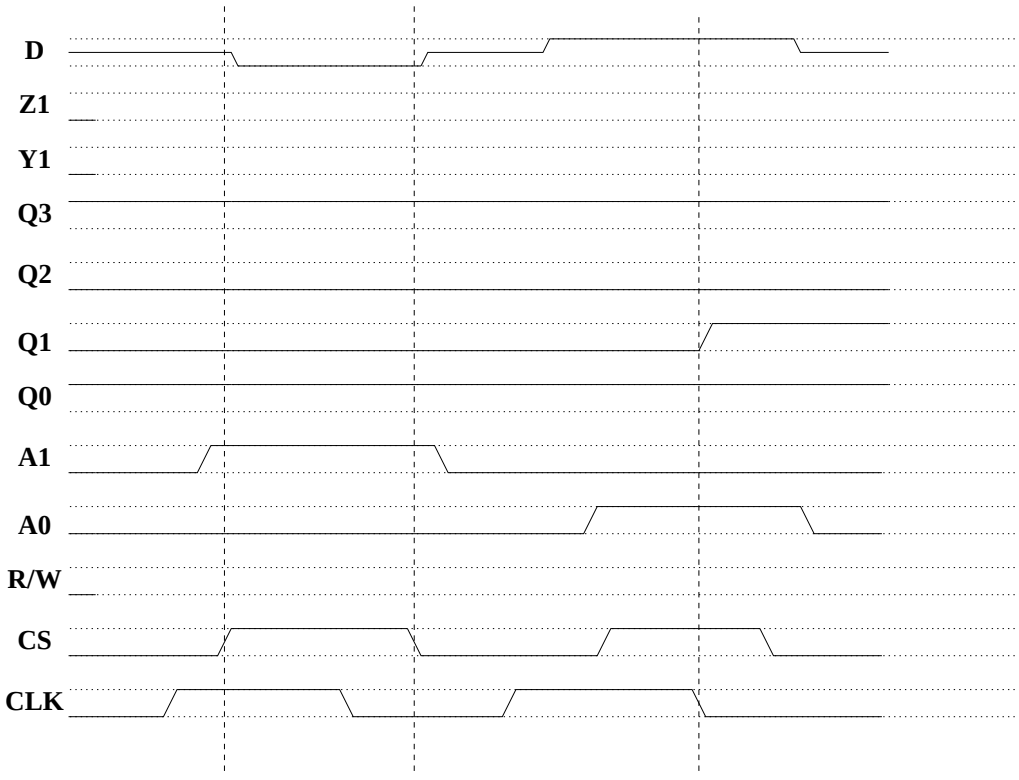
(d) (5 pts) If you interpret $Q2, Q1, Q0$ as a 3-bit number, what mathematical operations does this device perform on each clock cycle? Give one answer for each of $A = 0$ and $A = 1$

3. **Memory** (20 pts)

Consider the following circuit for a single bit memory element (this is one of four bits in our memory chip):



(a) (10 pts) For the timing diagram below, fill in the missing control signals: R/W, Y1, and Z1 (the Y's and Z's for the other bits are not shown below and you do not need to provide them). Note: there are two possible (but overlapping) answers. Pick one.

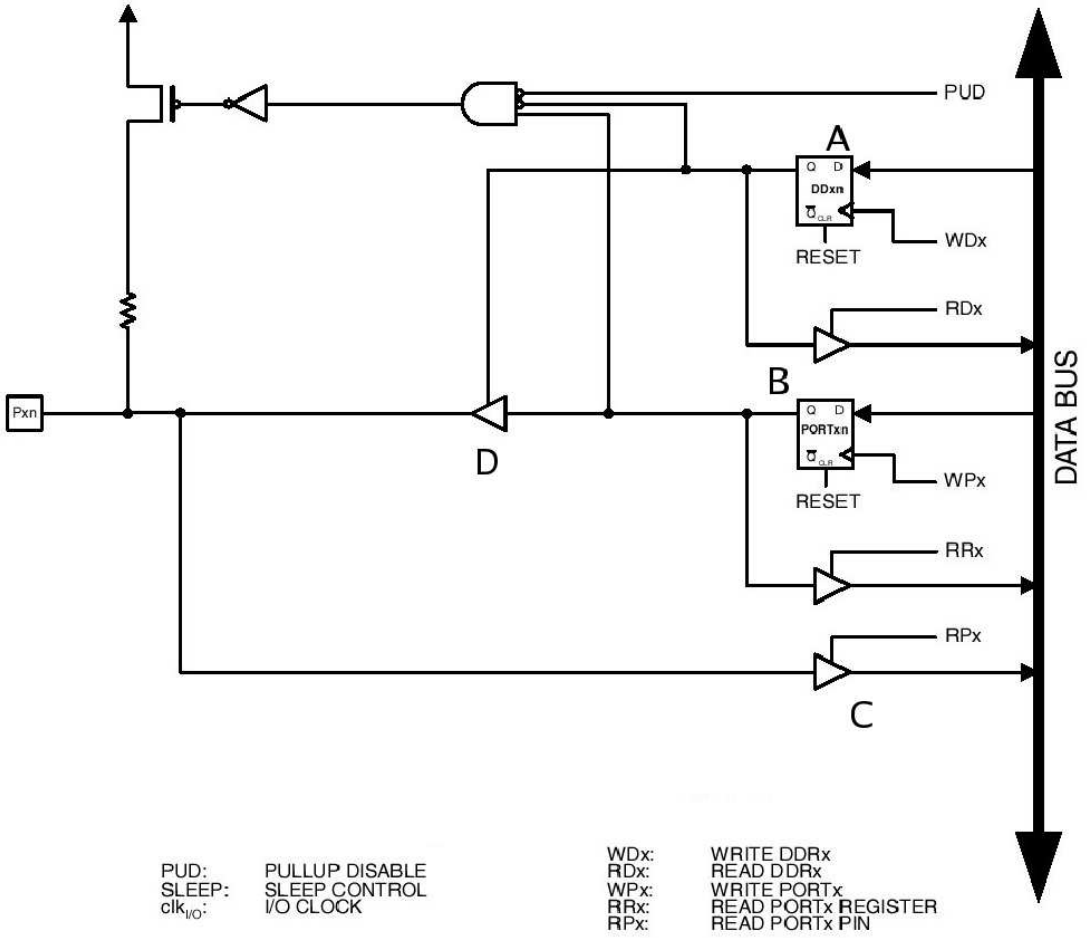


(b) (5 pts) What is the function of the *general purpose registers*? (be brief)

(c) (5 pts) True/False and explain: The chip select is an output from the memory chip.

4. **Microcontrollers** (25 pts)

Here is a diagram of a generic pin and its associated components.



Assume an initial state of:
$DDRC = 0x36$
$PORTC = 0x24$

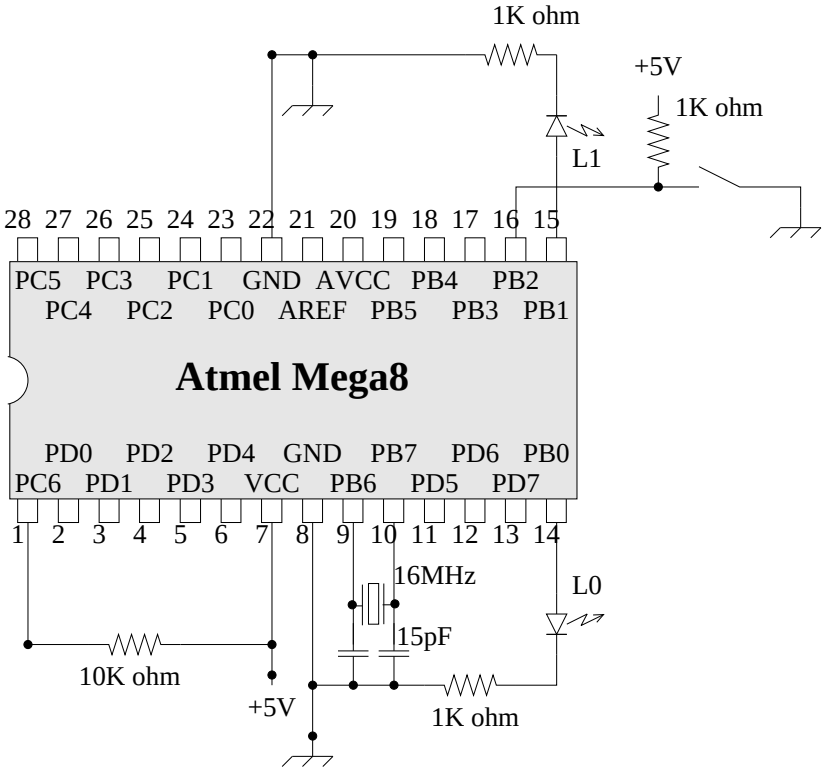
(a) (5 pts) What effect does the following code have on $DDRC$ and on the above circuit (in terms of components A, B, C, and D)? Be specific.

```
DDRC = DDRC | 0x1;
```

(b) (5 pts) What effect does the following code have on the state of this circuit (in terms of components A, B, C, and D)? Be specific.

```
PORTC = PORTC & ~0x02;
```

Consider the following circuit:



And consider the following code snippet:

```
DDRB = 0x3;

while(1) {
  if(PINB & 0x4) {
    PORTB |= 6;
    PORTB ^= 1;
    delay_ms(200);
  }else{
    PORTB |= 1;
    PORTB ^= 10;
    delay_ms(400);
  }
}
```

(c) (5 pts) What happens to the LEDs when the switch is open (no connection)?

(d) (5 pts) What happens to the LEDs when the switch is closed?

(e) (5 pts) Briefly define a *bus*.

5. **Serial Communication** (15 pts)

(a) (5 pts) Briefly describe the function of a *start bit* in asynchronous serial protocols (such as the one that we are using to communicate between the Atmel chip and the compass module).

(b) (10 pts) Assume that the next three characters to be read from the serial port are '5', '2' and '6'. What is the value of variable *val* in decimal after the following code completes its execution?

```
int i;
int val = 0;

for(i = 0; i < 2; ++i) {
   val = val * 8 + getchar() - '0';
}
```