CS 33 Fall 2014 Homework 2

It is apparent from the midterm exam that we need more instruction in using the Boolean functions and the combinations of arithmetic and shifting operations. In question 9 of the exam, you were asked to match an expression to a set of formulas involving Boolean, shifting and arithmetic operations.

Let's take a couple of the formulas offered as choices in the exam and explore how they work.

Let's use 16 bit integers: short a,b ; w = 16 and W, used in the formulas, is the word width-1 = 15. So, MAX_INT = 2^{15} -1 = 32,767 and MIN_INT = -2^{15} = -32768.

1) Many people answered that a >> 2 was the formula for a / 4. Well, yes, unless a is negative!

So, write a little program which has a loop on a going from 5 to -5. Print out the values of a, a/4 and a >>2 to see what is wrong with that answer. The correct answer was:

```
((a < 0 ? (a + 3) : a ) >> 2
```

in other words, (a + 3) >> 2 is used when a < 0 and a >> 2 is used otherwise. Add a+3 and (a+3)>>2 to your print statement.

2) Why is a ^ (MIN_INT + MAX_INT) the formula for the one's complement of a ?

Let's use our tool: to_binary from LAB1. If you do not have a working version of the function, I have posted it on the HW2 course materials. Be careful because in to_binary, w is the number of bits in the word = 16, not W = 15.

Add to your "little program" to

a) print out the x array as the result of

```
to_binary( MIN_INT + MAX_INT, W, x ) ;
```

Note that you will have to change the parameter a in to_binary from int to short.

b) add a loop for a from 5 to -5 and print out the y array as a result of

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to_binary( a, W, y, int &o ) ;
```

and also the z array which is the result of

to_binary(a ^ (MIN_INT + MAX_INT), W, z, int &o) ;

3) Is ~b the one's complement of b ?

set a = 3;

a) print out the results of to_binary for ~a.

add a loop to your program for b going from 5 to -5.

b) print out the results of to_binary for b and ~b.

a formula for a & b is ~(~a | (b ^ (MIN_INT + MAX_INT))), noting that the last part is the one's complement of b.

c) print out the results of to_binary for ~(~a | ~b) ... is this an example of DeMorgan's Law ?

For all of the work above, study the outputs to get a better understanding of how the Boolean and shift operations behave.

The submission shall be the .c or .cpp program. The assignment is due 6PM Nov 2. You can submit it early and multiple times.