Introduction to Digital Computers / Computer Structure - Spring 2003
Review Questions

Not to be handed in - This is for you to measure yourselves

1. Answer the 1st question in the exam "2000-a" that appears in the course homepage.
2. A generalized comparison operation is defined as follows:
   Input: $a, b \in \{0,1\}^n$
   Output: $y \in \{0,1\}^n$
   Functionality: $y_i = 1 \Leftrightarrow a[i:0] = b[i:0]$

   Propose a combinational circuit to implement generalized comparison. The goal is to achieve:

   - $Cost(n) \leq 8n$, and
   - $Delay(n) \leq 4 \cdot \log_2 n$ with respect to "Motorola" technology.
3. A weight calculator is defined as follows:
   Input: $x \in \{0,1\}^n$
   Output: $wt(x[i:0]), \quad i = 0, 1, \ldots, n$
   Try to design the fastest possible circuit. Can you achieve $O(\log n)$ delay?
4. What does a two's complement adder output when an overflow occurs? Let:
   - $a[n-1:0], b[n-1:0] \in \{0,1\}^n$; and
   - $z = [a[n-1:0]] + [b[n-1:0]]$.

   Suppose that
   $$\langle c[n] \cdot s[n-1:0] \rangle = \langle a[n-1:0] \rangle + \langle b[n-1:0] \rangle.$$
   Prove that:

   (a)
   $$[s[n-1:0]] = z \pmod{2^n}$$

   (b) Suppose that $z \notin T_n$ and that $z > 0$. Write the smallest interval that z belongs to. Write a closed formula for $[s[n-1:0]]$. What is the interval that $[s[n-1:0]]$ belongs to?

   (c) Suppose that $z \notin T_n$ and that $z < 0$. Write the smallest interval that z belongs to. Write a closed formula for $[s[n-1:0]]$. What is the interval that $[s[n-1:0]]$ belongs to?

   (d) Write and execute a C program that demonstrates your answers. Clue: a and b are added as unsigned and stored in an unsigned variable s. Print a, b, and s as signed integers. (You may use another programming language if you like.)