Department of Electrical and Computer Engineering

The University of Texas at Austin

EE 306, Fall 2021
Problem Set 1
Due: September 13, before class
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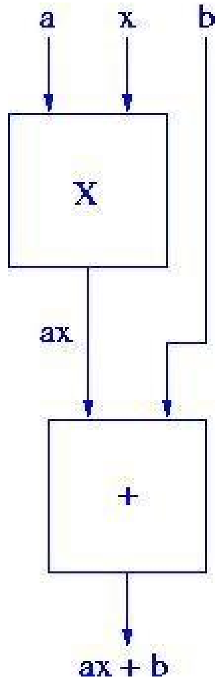
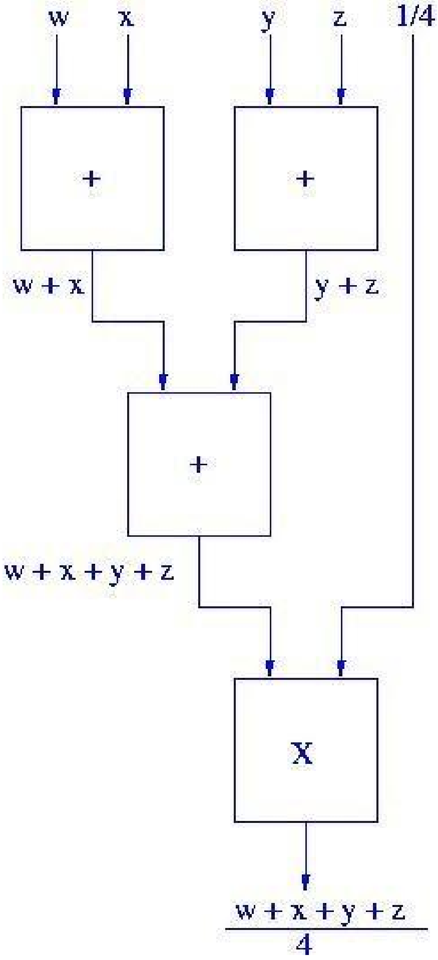
Please turn in the Student Information Sheet with a recognizable photograph on the same day you turn in this problem set.

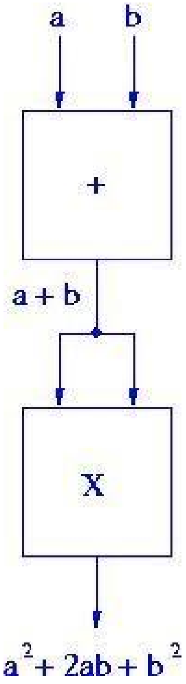
1. (Adapted from problem 1.5 in the textbook)
   Say we had a "black box," which takes two numbers as input and outputs their sum. See Figure 1.7a in the Textbook. Say we had another box capable of multiplying two numbers together. See figure 1.7b. We can connect these boxes together to calculate p * (m + n). See Figure 1.7c. Assume we have an unlimited number of these boxes. Show how to connect them together to calculate:
   a. ax+b



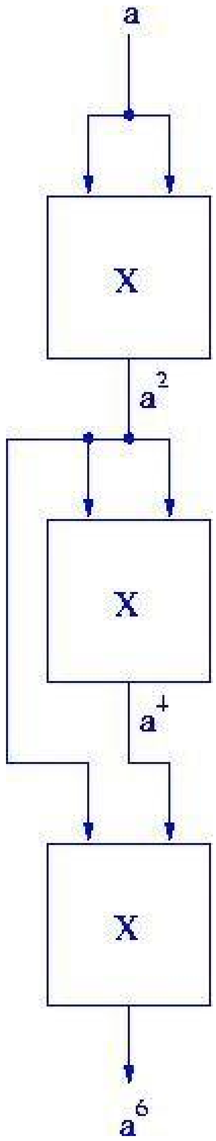
b. The average of the four input numbers w, x, y, and z



c. $a^2 + 2ab + b^2$ (can you do it with one add box and one multiply box?)



d. a^6 (can you do it using only 3 multiply boxes?)



2. (1.14)
Suppose we wish to put a set of names in alphabetical order. We call the act of doing so sorting. One algorithm that can accomplish that is called the bubble sort. We could then program our bubble sort algorithm in C, and compile the C program to execute on an x86 ISA. The x86 ISA can be implemented with an Intel Core microarchitecture. Let us call the sequence "Bubble Sort, C program, x86 ISA, Core microarchitecture" one transformation process.
Assume we have available four sorting algorithms and can program in C, C++, Pascal, Fortran, and COBOL. We have available compilers that can translate from each of these to either x86 or SPARC, and we have available three different microarchitectures for x86 and three different microarchitectures for SPARC.

a. How many transformation processes are possible?

   120

b. Write three examples of transformation processes.

   1. Bubble sort, c++, x86, Core microarchitecture
   2. Bubble sort, COBOL, x86, Core microarchitecture
   3. Bubble sort, Pascal, x86, Core microarchitecture

c. How many transformation processes are possible if instead of three different microarchitectures for x86 and three different microarchitectures for SPARC, there were three for x86 and five for SPARC.

   160

3. (2.3)
   a. Assume that there are about 400 students in your class. If every student is to be assigned a unique bit pattern, what is the minimum number of bits required to do this?

      9

   b. How many more students can be admitted to the class without requiring additional bits for each student's unique bit pattern?

      112

4. (Adapted from 2.13)
   Without changing their values, convert the following 2's complement binary numbers into 8-bit 2's complement numbers.
   a. 010110

      00010110

   b. 1101

      11111101

   c. 1111111000

      11111000

   d. 01

      00000001

5. (Adapted from 2.17)
   Compute the following. Assume each operand is a 2's complement binary number.
   a. 01 + 1011

      1100

   b. 11 + 01010101

      01010100

   c. 0101 + 110

      0011

   d. 10101 + 01010

      11111

6. For the following 8-bit binary numbers, write down the decimal number they represent as unsigned, signed magnitude, 1’s complement, and 2’s complement representations, respectively.
   a. 01010101

      unsigned: 85, signed magnitude: 85,
      1’s complement: 85, 2’s complement: 85

   b. 10000000

      unsigned: 128, signed magnitude: -0,
      1’s complement: -127, 2’s complement: -128

   c. 11111111

      unsigned: 255, signed magnitude: -127,
      1’s complement: -0, 2’s complement: -1

7. Express the value 0.3 in the 32-bit floating point format that we discussed in class today. Feel free to only show fraction bits [22:15], rather than all the fraction bits, [22:0]. Notation: The symbol [22:15] signifies all 8 bits from bit 22 to bit 15.

   0 01111101 00110011

8. Convert the following floating point representation to its decimal equivalent:
   a. 1 10000010 10101001100000000000000

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   b. 1 11111111 00000000000000000000000

      -∞ (negative infinity)

   c. 0 00000000 00000001000000000000000

      2^{-134}

9. (This question is postponed and the answer will be provided in Problem Set 2 solution) (Adapted from 2.50)
   Perform the following logical operations. Express your answers in hexadecimal notation.

   a. xABCD OR x9876

   b. x1234 XOR x1234

   c. xFEED AND (NOT(xBEEF))

10. (2.54)
    Fill In the truth table for the equations given. The first line is done as an example.

Q1 = NOT (NOT(X) OR (X AND Y AND Z))
Q2 = NOT ((Y OR Z) AND (X AND Y AND Z))

X	Y	Z	Q1	Q2
0	0	0	0	1
0	0	1	0	1
0	1	0	0	1
0	1	1	0	1
1	0	0	1	1
1	0	1	1	1
1	1	0	1	1
1	1	1	0	0