Midterm Exam

20 March 2019

Practice version

Do not write your name on the exam paper. Instead, a sign-in sheet is coming around. Choose any of the sign-in codes, write your name next to it, and then copy that code to the top front of **each page** of the exam.

You have up to 1 hour, 45 minutes. You may use a calculator, but no text book or notes.

1. For each statement below, fill in the blank with the *best* term from the following list. Some terms might be used more than once; some might not be used at all.

   • ASCII • binary • bit • Boolean • byte • compression • CPU • hexadecimal • input • lossless • lossy • octal • output • pixel • resolution • tree • two's complement • Unicode

   - In the von Neumann architecture, a device that receives data *from* the CPU is called ____________________
   - ____________________ is a format for binary numbers that supports both positive or negative numbers.
   - ____________________ is a 7-bit code for representing the characters used in American English.
   - A compression technique is called ____________________ if decompression cannot reproduce the original data perfectly.
   - A(n) ____________________ is a structure in computer science for representing data at branches and leaves.

2. Convert the following base ten (decimal) numbers into binary, using as many bits as needed.

   - 14 = ____________________
   - 25 = ____________________
   - 86 = ____________________

3. Convert the following 5-bit **signed two's complement** binary numbers into base ten. **Note:** "signed" means that answers **might be negative.**

    - `01011` = ____________________
    - `10011` = ____________________
    - `01111` = ____________________
    - `11000` = ____________________
    - `00101` = ____________________

4. Add the following pairs of 4-bit **fixed-size unsigned** binary numbers. Your answers must be in binary, but you should check you work by converting to base ten.

```
 1001   =           0110   =           1100   =
 1100   =           0101   =           0111   =
_______   _____   _______   _____   _______   _____
```

5. Convert the following binary number to octal and hexadecimal:

```
1 1 1 1 0 0 0 1 0 1 1 0 0 0 1 1 1 0 0 1 0 0
```

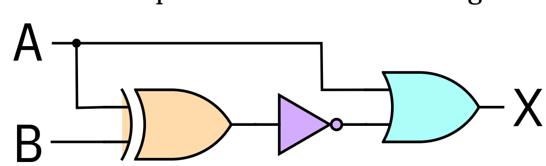
6. Suppose we want to design a custom character encoding just for the word **REVERE**

   (a) How many bits would we need to represent **each distinct letter** if using a **fixed-width** encoding? _____

   (b) Using the fixed-width representation in the previous question, how many bits would we need to encode the entire word **REVERE**? _____

   (c) Draw a tree to represent a **variable-width** encoding of these letters. Use your tree to encode the word **REVERE**. How many bits did you need? _____

7. Which Boolean expression is equivalent to the following circuit diagram?



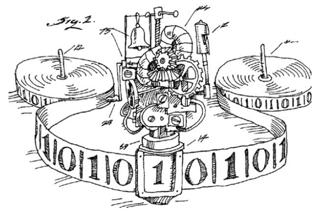
   (a) $X = A' + (A \oplus B)$

   (b) $X = A + (A \oplus B)'$

   (c) $X = A \oplus (A + B)'$

   (d) $X = A + (A \oplus B')$

8. This problem is about a program for a Turing Machine. Recall that a TM operates by reading and writing symbols on a tape that can be spooled to the left and right. For our program, each cell on the tape can contain either a zero (0), a one (1), or it can be blank (B).



The table below is a representation of a particular TM program. The TM keeps track of its current **state**, a small integer starting at 0.

The first row of the table says that if we're in state 0, and the symbol on the tape at the current position is a 0, we should write a **1** to that position, move the position to the **Right**, and stay in state **0**.

If the "next state" differs from the current state, that represents a **transition**. Use the new state for subsequent operations. Computation continues according to the instructions in the table, until we reach the "halt" state, when the machine stops.

rule number	current state	current symbol	write symbol	move to	next state
1	0	0	1	R	0
2	0	1	0	R	0
3	0	B	B	L	1
4	1	0	1	R	halt
5	1	1	0	L	1
6	1	B	1	L	halt

Simulate the execution of the above Turing Machine program on a tape containing a 4-bit number surrounded by blanks, as shown below. The starting position is underlined (it's the leftmost 1):

···	B	B	$\underline{1}$	1	0	0	B	B	···

What will be the contents of the tape when the machine halts? ____________________