**CSC 180, Lab #5**
**Fall 2021**

***Directions:*** Turn in a hard copy of this assignment, with your answers written on this or another sheet of paper. Circuits created in CircuitVerse should be printed out as described in class.

1. Suppose that X = 4 and Y = 10. Evaluate the following using Boolean logic [10 points]

   a. X > 10

   b. X < 6 AND Y > 0

   c. X < 6 AND NOT (Y = 10)

   d. X < 6 OR Y > 100

   e. X < 6 XOR Y > 100

2. Use Boolean logic to write a condition corresponding to the following: [6 points]

   a. A person's full name is "Angela Robbins". (Note: you must check both the *first* and *last* name)

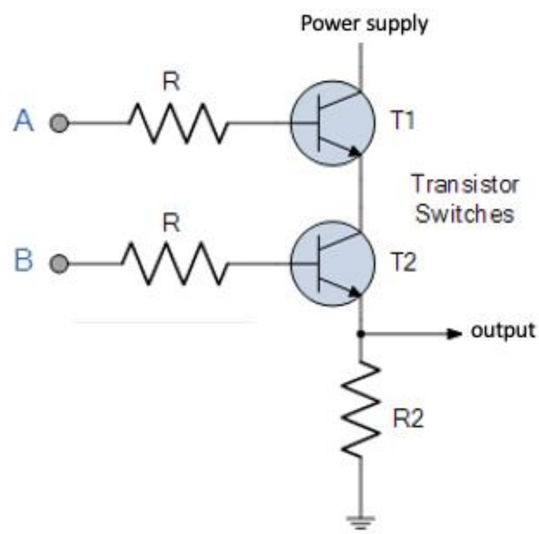
   b. A student lives in Connecticut or New York

   c. The variables X, Y, and Z all have the same value

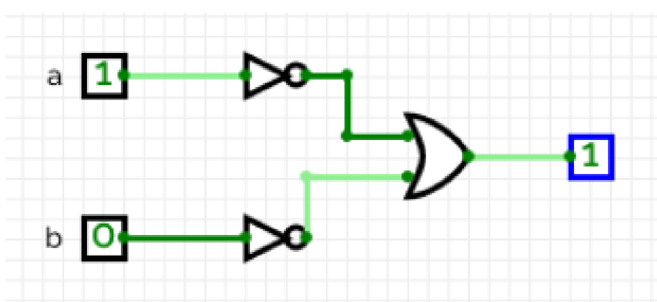
3. A logical gate created from 2 transistors is shown on the next page. [6 points]

   a. If A = 1, which of the following is True regarding the transistor T1?
      i. The transistor switch is CLOSED and the transistor is ON.
      ii. The transistor switch is OPEN and the transistor is ON
      iii. The transistor switch is CLOSED and the transistor is OFF.
      iv. The transistor switch is OPEN and the transistor is OFF.

b. What is the output if A = 1 and B = 0? Explain, in words, why this is the case?




4. What is the Boolean expression implemented in the circuit below? [4 points]




5. Use CircuitVerse to create a circuit that implements the “identity comparator” using only AND, NOT, and OR gates. An “identity comparator” circuit takes two binary inputs, *a* and *b*, and outputs 1 if *a* and *b* are the same (either both 0 or both 1). (Hint: See the “identity comparator” example from the Notes). [6 points]

6. A truth table is given below for three inputs, *a*, *b*, and *c,* and an output that indicates whether all inputs are the same. Specify the Boolean expression that results in the *output* for the table below. Then create the circuit using CircuitVerse. [10 points]. Note: We will only work with logical gates that have 2 inputs. Therefore, for Boolean expressions that have 3 inputs, you will have to use multiple gates. For an example, see: https://circuitverse.org/users/89029/projects/logical-and-with-3-inputs

| a | b | c | output |
|---|---|---|---|
| 1 | 1 | 1 | 1 |
| 1 | 1 | 0 | 0 |
| 1 | 0 | 1 | 0 |
| 1 | 0 | 0 | 0 |
| 0 | 1 | 1 | 0 |
| 0 | 1 | 0 | 0 |
| 0 | 0 | 1 | 0 |
| 0 | 0 | 0 | 1 |

7. An identity comparator circuit can also be implemented using an XNOR (NOT XOR) gate. This is because an XOR gate will output a 1 if its inputs are different. Therefore, a NOT XOR (XNOR) gate will output a 1 if its inputs are the *same*, and will output a 0 otherwise. XNOR can therefore be used to determine if the single bit inputs *a* and *b* are the same. But what if *a* and *b* were more than 1 bit? For this problem, you will construct a circuit where *a* and *b* are each 2 bits. In general, *a* and *b* are the same if each of their binary digits are the same. Let $a = a_1a_2$ and $b = b_1b_2$, where the subscript 1 denotes the 1$^{st}$ (left-most) bit and the subscript 2 denotes the 2$^{nd}$ (right-most) bit.

   A circuit testing for equality can be defined by

   $a_1$ XNOR $b_1$ AND $a_2$ XNOR $b_2$

   Create this circuit in CircuitVerse, using this circuit as a starting point: https://circuitverse.org/users/89029/projects/question-6-452459da-e589-4a3c-be63-ac92c85edd47

   Note: this logic can be extended to compare numbers that are > 2 bits. [8 points]