CSC 180, Lab #7 **Name: _____[3 points]**
Fall 2024

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. How many memory addresses can be accessed using a decoder with 3 inputs? [5 points]

2. How many input lines are needed to access 1024 memory addresses? [5 points]

3. Suppose that a memory unit containing 256 MB (2^{28} bytes) is organized into a two-dimensional array. How many input lines are needed for the *row* decoder? [5 points]

4. Create a circuit for an ALU that uses a multiplexer to either add or subtract two numbers. In other words, the circuit calculates A + B and A – B, and the multiplexer selects one of these results to output. Note that A – B is the same as adding A to the two's complement of B. The inputs should each have 3 binary digits, which you can specify by setting the BitWidth (you will need to set the BitWidth appropriately for each element). Note that you should use the built-in circuits for the multiplexer, the adder, and for finding the two's complement. [15 points]

5. Find the sum of the binary values of 011 and 010, and specify the corresponding calculation when the numbers are converted to decimal using two's complement (e.g., 011 corresponds to the decimal value 3). Note that the answer will not be correct! Why? [10 points]

6. Using the machine learning operations provided in Figure 5.25 of the notes, specify the machine learning instructions that correspond to the Python code below. Note that after the code is executed, *x* will hold the value entered by the user and *y* will store the value of *x* plus 1. Note that when Python code is executed, it must ultimately be converted to machine code that the computer can understand. [10 points]

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x = int(input())
y = x + 1
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7. Recall that each operation has a binary op code, given in Figure 5.25. We will use 8 bits for the op code, so for example, STORE X has the opcode 00000001. Complete the table below by specifying the binary machine instructions (op code and address) corresponding "Set *a* to the value of *b* + *c*" from the notes. Note that the addresses will need to be converted into binary using 8 digits. [12 points]

Instruction Address	Contents	Commentary	Op Code	Address
50	LOAD 101	Put the value of *b* into register *R*		
51	ADD 102	Add *c* to register *R* (it now holds *b* + *c*)		
52	STORE 100	Store the contents of register *R* into *a*		

How many bytes are required for the instruction register (IR) in this example?