Complete the following problems. Be sure to show your work for partial credit.

1. An \(m\)-bit thermometer code for the number \(k\) consists of \(k\) 1’s in the least significant bit positions and \(m - k\) 0’s in all the more significant bit positions. A binary-to-thermometer converter has \(n\) inputs and \(2^n - 1\) outputs. It produces a \(2^n - 1\) bit thermometer code for the number specified by the input. For example, if the input is 110, the output should be 0111111. Design a 3:7 binary-to-thermometer code converter. Specify your design in the way that seems most natural to you, using a block diagram, schematic, or boolean expression (or some combination of these).

2. Design a modified priority encoder that receives an 8-bit input, \(A_{7:0}\), and produces two 3-bit outputs, \(Y_{2:0}\) and \(Z_{2:0}\) and two 1-bit outputs, \(v\) and \(w\). \(v\) should be TRUE if there are one or more TRUE bits on the input. \(Y\) indicates the most significant bit of the input that is TRUE. \(w\) should be TRUE if there are two or more TRUE bits on the input. \(Z\) indicates the second most significant bit of the input that is TRUE. Specify your design in the way that seems most natural to you, using a block diagram, schematic, or boolean expression (or some combination of these).

3. Design a full adder module with data inputs \(A\) and \(B\), carry input \(C_{in}\), sum output \(S\), and carry output \(C_{out}\).
   (a) Using two half adder modules.
   (b) Using a 3:8 decoder and NAND gates.
   (c) Using a four input, 2-bit multiplexer.

4. Design a 4-bit comparator. This comparator takes two 4-bit operands, \(A_{3:0}\) and \(B_{3:0}\) and has three outputs \(L\), \(E\), and \(G\). The outputs are true when \(A < B\), \(A = B\), and \(A > B\) respectively. Define a single-bit comparator module and show
   (a) how they are wired together to form a 4-bit comparator, and
   (b) boolean expressions describing the behavior of this module