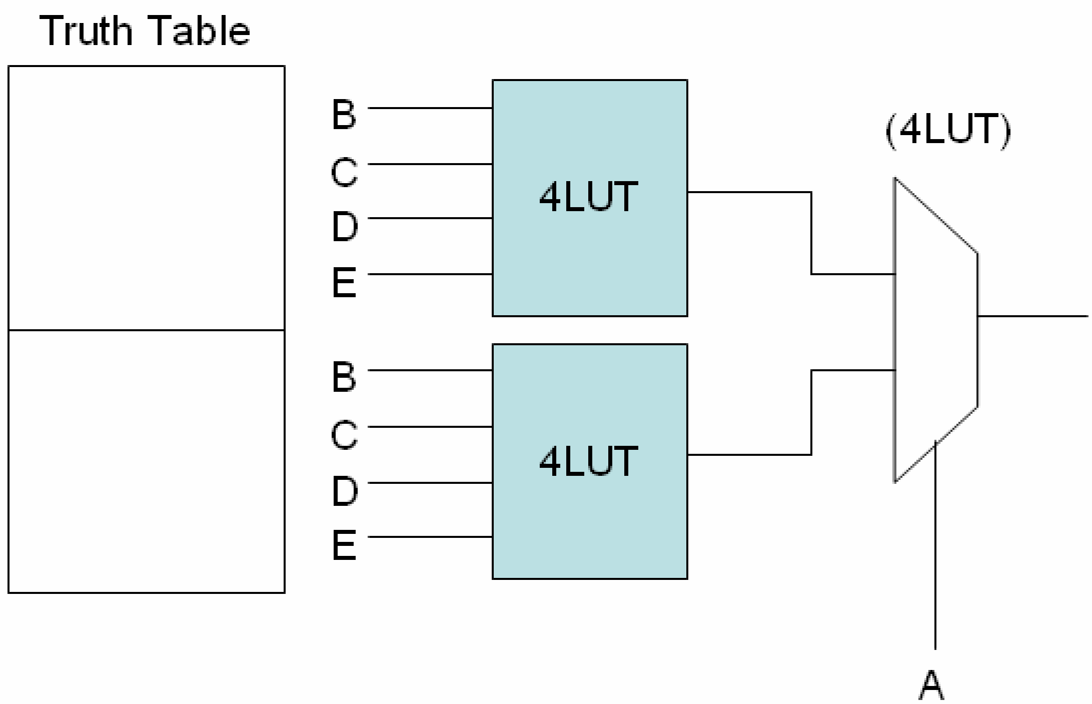
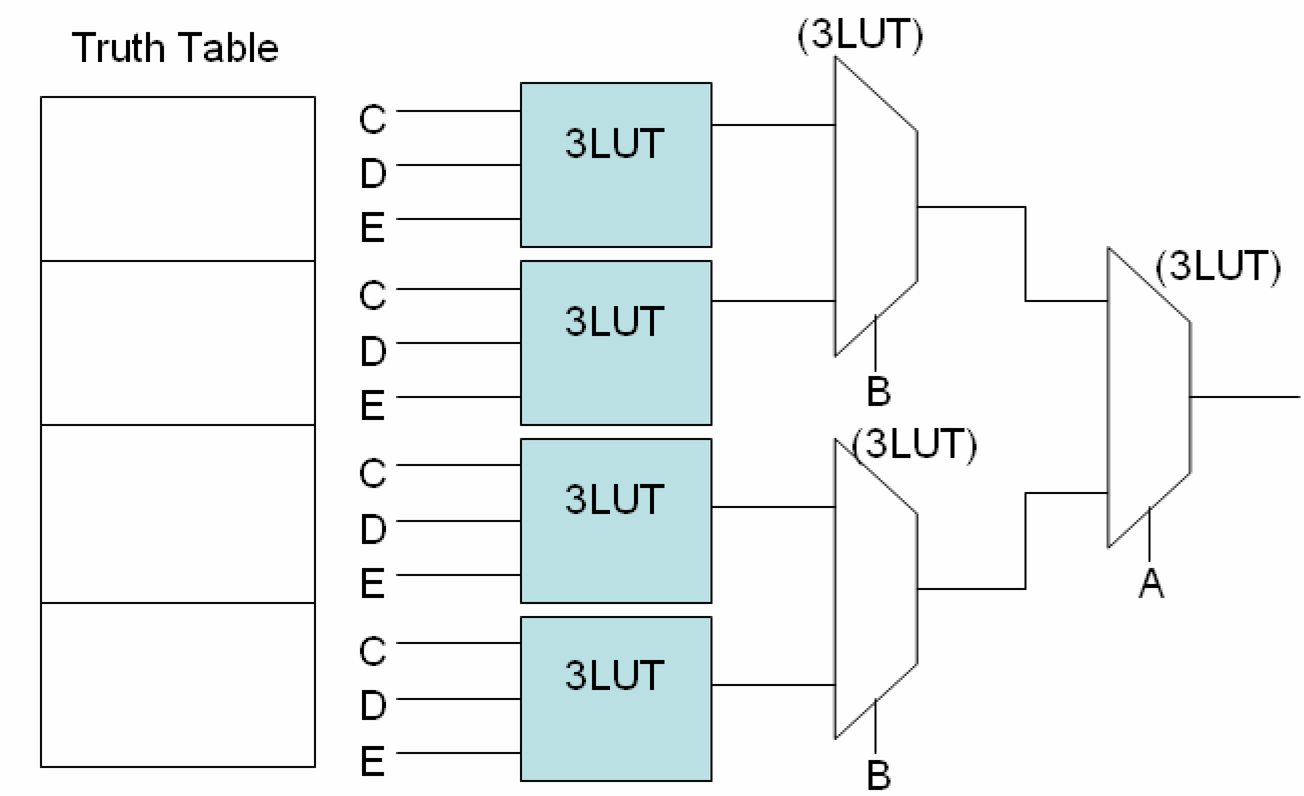
ECEn/CS 224
Chapter 19 Homework Solutions

19.1 Show how to implement a 5-input function using 4LUTs. HINT: the decomposition is very similar to that done using MUX blocks previously in this text. Consult that section for ideas on how to accomplish it. Next, show how to implement a 5-input function using 3LUTs.

We require **three 4LUTs** to implement the 5-input function.



We require **seven 3LUTs** to implement the same function:



19.2 Derive a formula showing how many 4LUTs it takes to implement a k-input function where $k \geq 4$. Express this formula in terms of k.

Each 4LUT implements 16 rows in a truth table. A k-input function has 2^k rows. The 1st level of 4LUTs will take $2^k/16$ units. These all have outputs which need to be MUXed together by 2:1 MUXes in the 2nd level. The 2nd level outputs will then be MUXed together by 2:1 MUXes in the 3rd level and so on.

For m inputs of a tree of 2:1 MUXes, it takes m-1 2:1 MUXes.

The formula is therefore: $2^k/16 + (2^k/16 - 1) = 2^{k+1}/16 - 1$

19.3 Consider the problem of using 4LUTs to implement a 9-input function. Show how you would do this.

A 9 input function has 512 rows in the Truth Table. This would take $512/2^4 = 32$ 4LUTs to implement. The 32 outputs would then go into a 2:1 MUX tree which uses 31 4LUTs. The total implementation therefore takes 32+31 = 63 4LUTs.

19.4 Repeat the above problem but use 3LUTs.

To implement 512 rows would take $512/2^3$ 64 3LUTs. The MUX tree would take 63 3LUTs. The total would therefore be 64+63 = 127 3LUTs.

19.5 Using Figure 19.10 as a template (print it out and color on it), complete the design of a circuit which will add two numbers. Call the numbers A and B. They are each three bits wide. Have your circuit generate a four-bit result and output it on pins. If your circuit will not fit onto one copy of Figure 19.10, make multiple copies and tape them together to obtain an FPGA fabric large enough for this design.