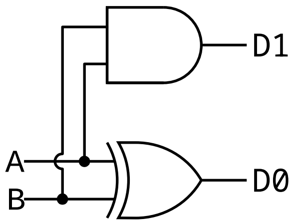
English Name: ____________________

Worksheet: Binary Adders

For the logic circuit to the right, fill out the truth table.

Consider the input as two single-digit binary numbers, and the output as a two-digit binary number. Notice that the circuit to the right is a binary adder able to add single-bit binary numbers. Verify this by comparing the output of the circuit to the calculations titled *Single Bit Binary Addition* below the truth table.

Unfortunately, in order to add binary numbers that span multiple digits, there is additional complexity: there may be a carry bit from the addition of the digits to the right.

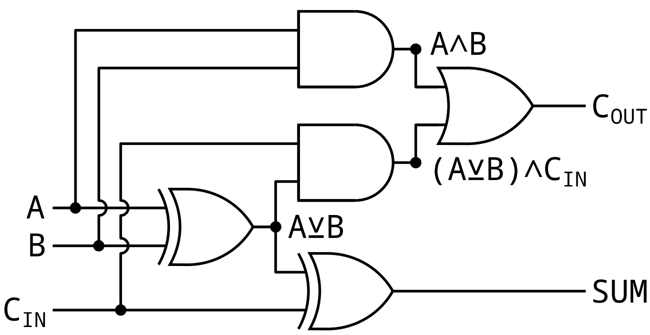


A	B	D1	D0
0	0	0	0
0	1	0	1
1	0	0	1
1	1	1	0

Single Bit Binary Addition

0	0	1	1
+0	+1	+0	+1
00	01	01	10

The circuit below implements a single-bit adder that handles a carry-in bit. Complete the truth table for this circuit.

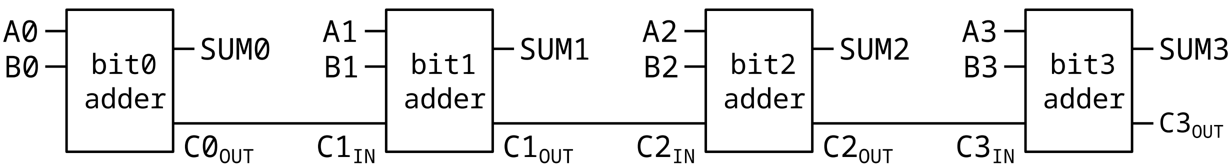


A	B	C_{IN}	A⊻B	**SUM**	A∧B	(A⊻B)∧C_{IN}	**C_{OUT}**
0	0	0	0	**0**	0	0	**0**
0	0	1	0	**1**	0	0	**0**
0	1	0	1	**1**	0	0	**0**
0	1	1	1	**0**	0	1	**1**
1	0	0	1	**1**	0	0	**0**
1	0	1	1	**0**	0	1	**1**
1	1	0	0	**0**	1	0	**1**
1	1	1	0	**1**	1	0	**1**

Since addition follows the commutative law, the order doesn't matter, the number of ones to be added count either zero, one, two, or three. Therefore, the four possible computations are:

0	0	0	1
0	0	1	1
+0	+1	+1	+1
00	01	10	11

In the diagram below, each "black box" contains the single-bit adder with carry-in that was examined above. (The least-significant bit can use the simpler version without a carry-in). This adder can be chained together to add two binary numbers of arbitrary length. Examine and understand the diagram.



In practice, this type of adder is slow because of the delay as the signal propagates through the adder chain. Modern processors can chain longer adders or use more efficient algorithms, such as carry look-ahead. These are beyond the scope of today's lesson. **What does the $C3_{OUT}$ bit represent?**