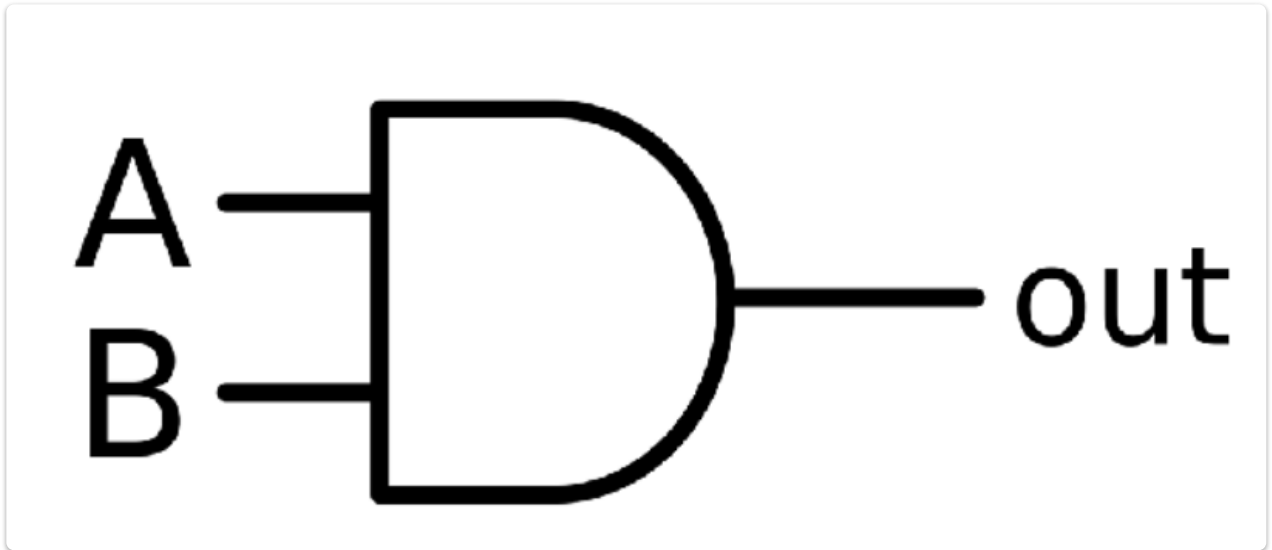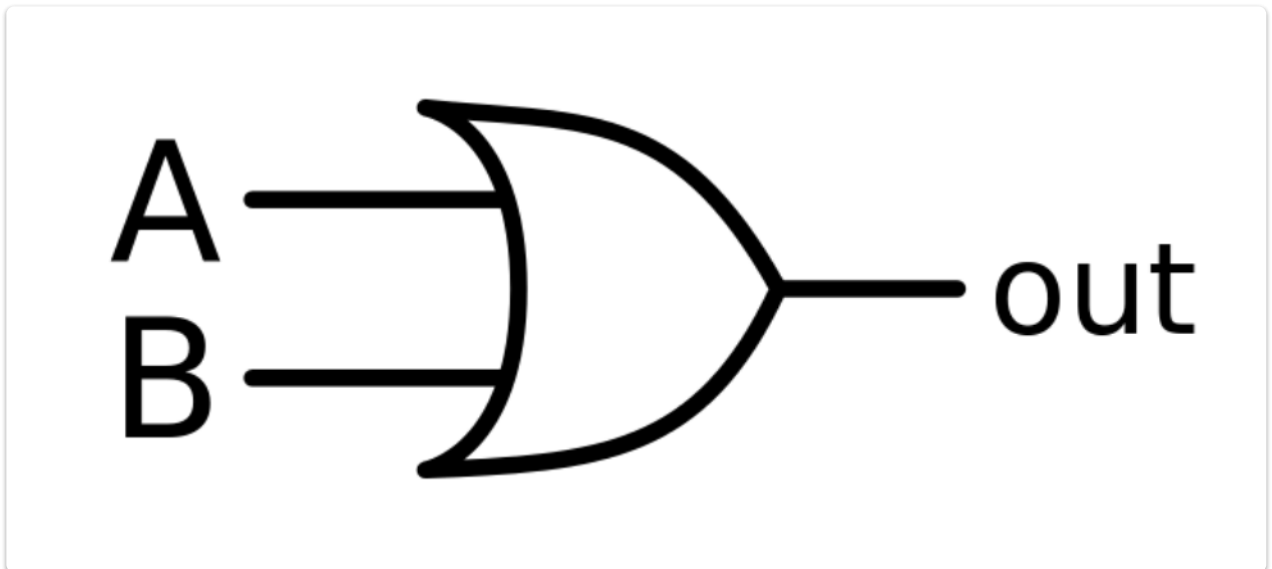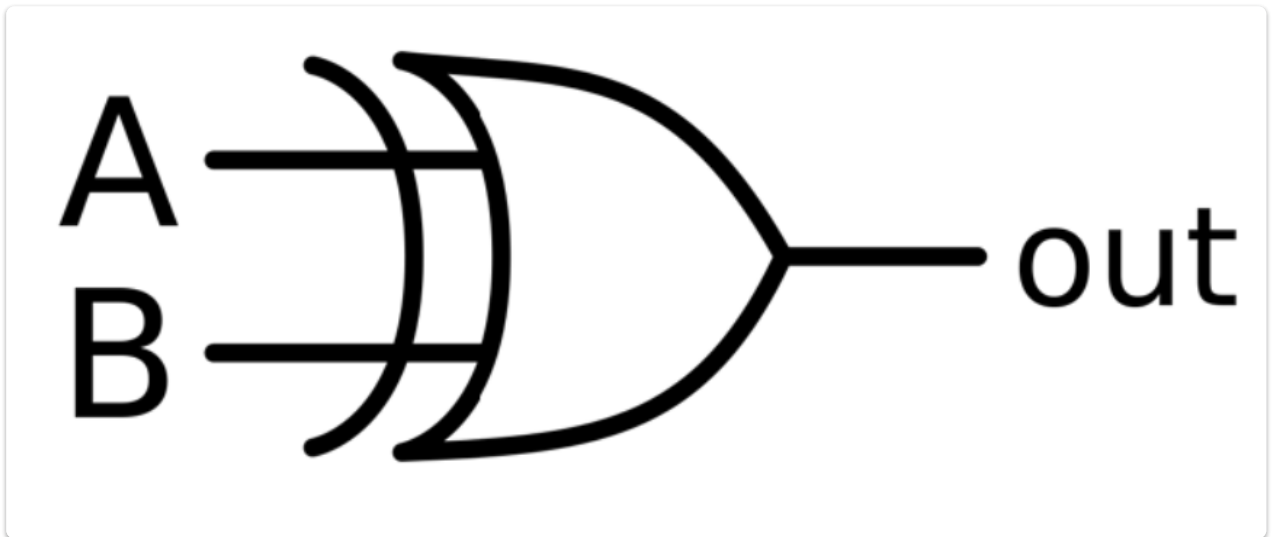# Logic Gates

- And

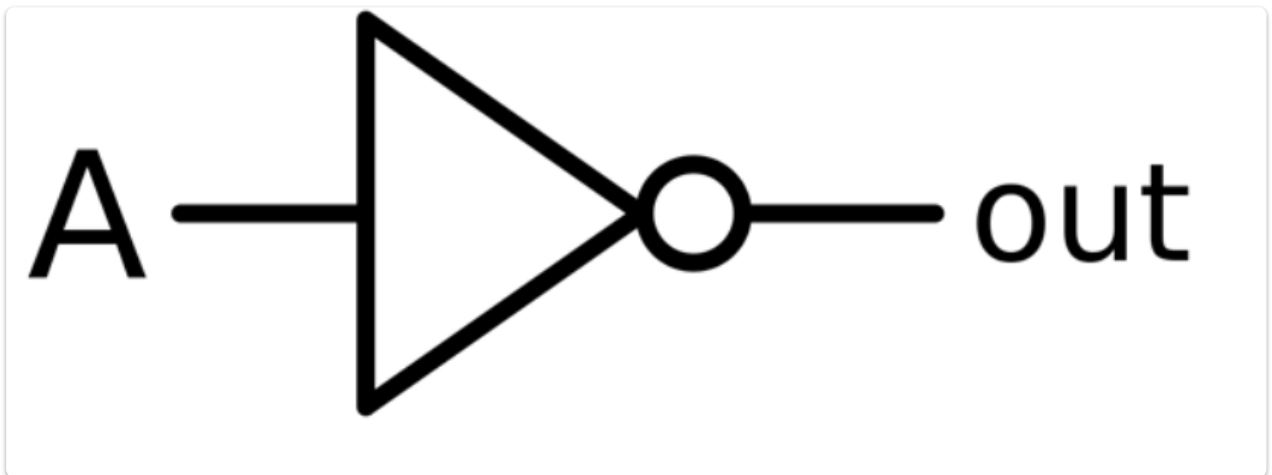consider the shape as a "D"

- OR

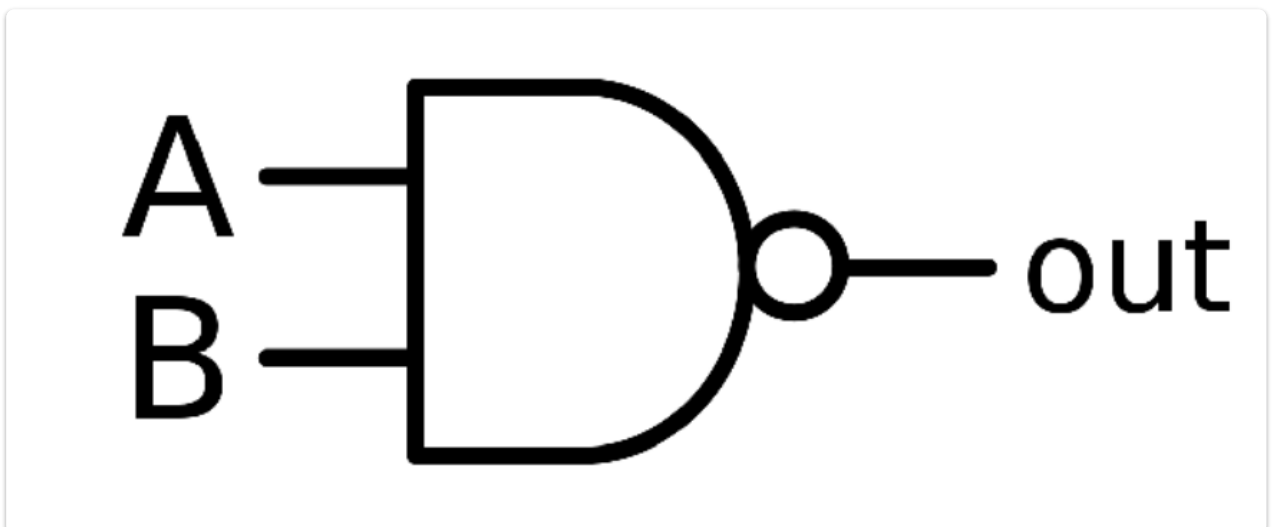consider the lhs shape as the half of "O"
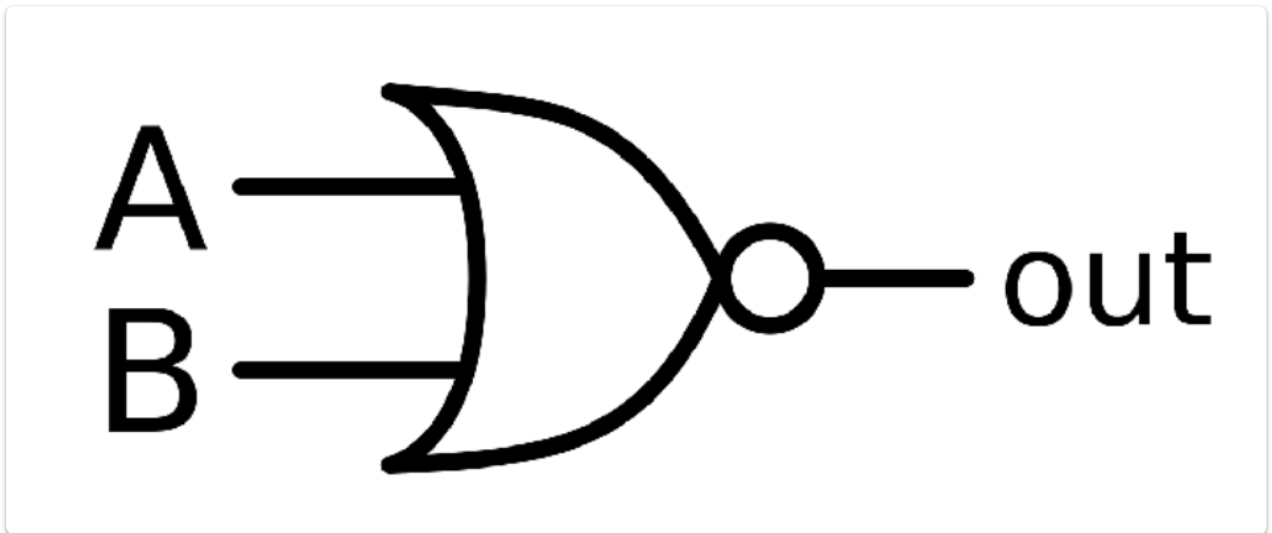
- XOR exclusive or

- NOT

The triangle without bubble is a buffer, which does nothing to input.
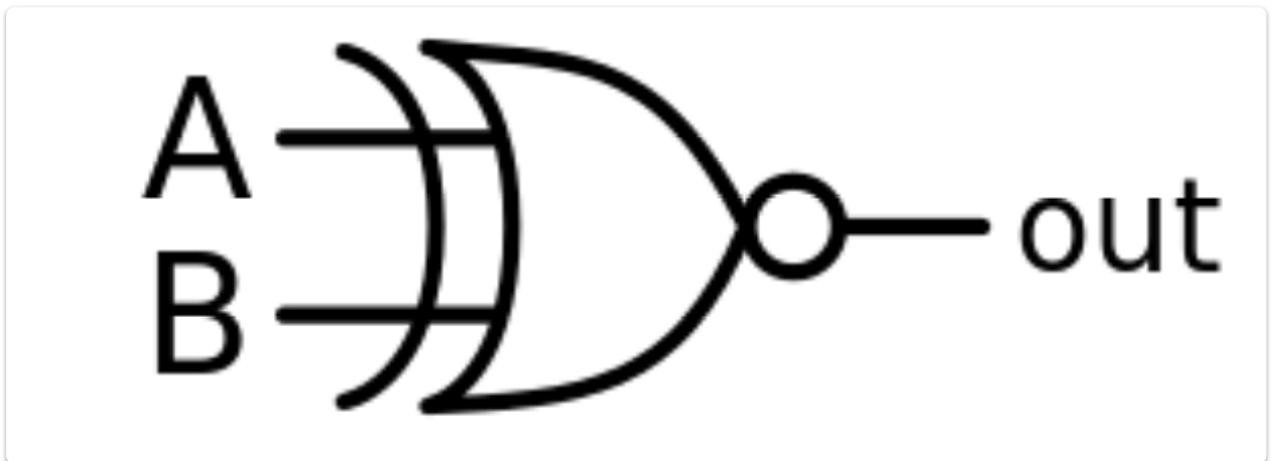
- NAND not and

- NOR not or

- NXOR not exclusive or

Boolean Algebra

Laws of Boolean Algebra

1. Complementary

$$A\bar{A} = 0 \qquad A + \bar{A} = 1$$

2. Idempotent

$$AA = A \qquad A + A = A$$

3. Commutativity

$$AB = BA \qquad A + B = B + A$$

4. Associativity

$$(AB)C = A(BC)$$

$$(A + B) + C = A + (B + C)$$

5. Distribution

$$A(B + C) = AB + AC$$

$$A + BC = (A + B)(A + C)$$

Adder

Half Adder (Ignore carry from last column)
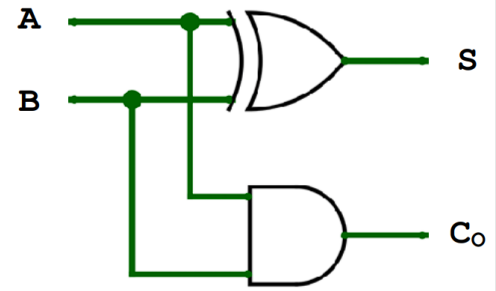
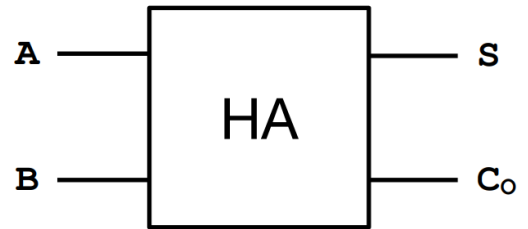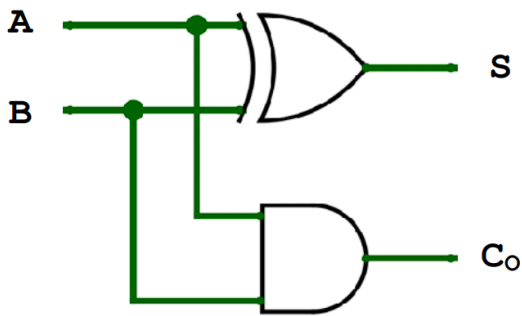| A	B	C_O	S
0	0	0	0
0	1	0	1
1	0	0	1
1	1	1	0

$$S = A \oplus B$$

$$C_O = AB$$

Half adder abstraction

Full Adder(Consider carry from last column)

Full Adder (single bit)

A	B	C_i	C_o	S
0	0	0	0	0
0	0	1	0	1
0	1	0	0	1
0	1	1	1	0
1	0	0	0	1
1	0	1	1	0
1	1	0	1	0
1	1	1	1	1

S is 1 when 1 or 3 of the bits are 1

$$S = A \oplus B \oplus C_i$$

$$S = A \oplus B \oplus C_i$$

$$C_O = AB + C_i(A \oplus B)$$

4-bit Adder

Computer Science 61C Spring 2022

McMahon and Weaver

$$C_3 \quad C_2 \quad C_1 \quad C_0 \quad C_{-1} = 0$$
$$\quad\quad A_3 \quad A_2 \quad A_1 \quad A_0$$
$$\quad\quad B_3 \quad B_2 \quad B_1 \quad B_0$$
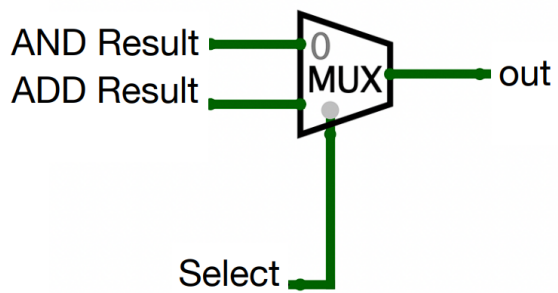$$\overline{\quad\quad S_3 \quad S_2 \quad S_1 \quad S_0}$$
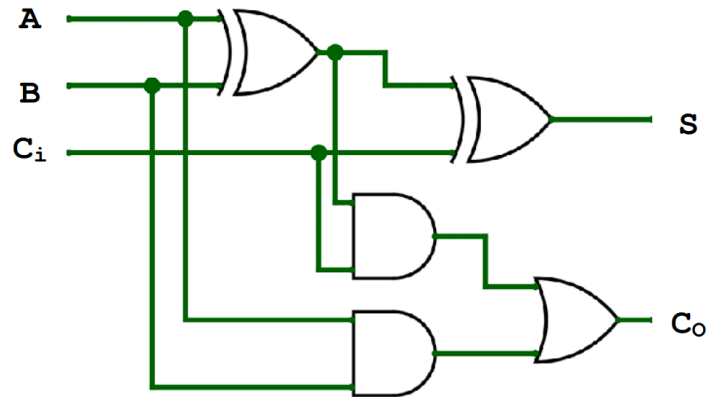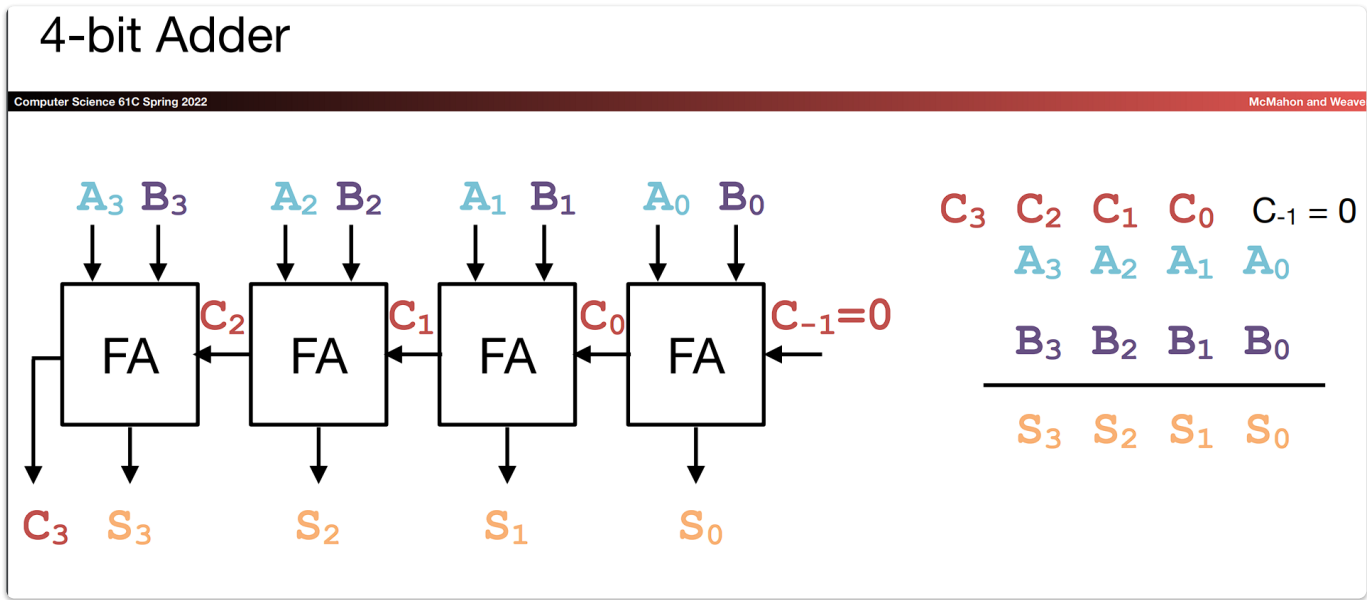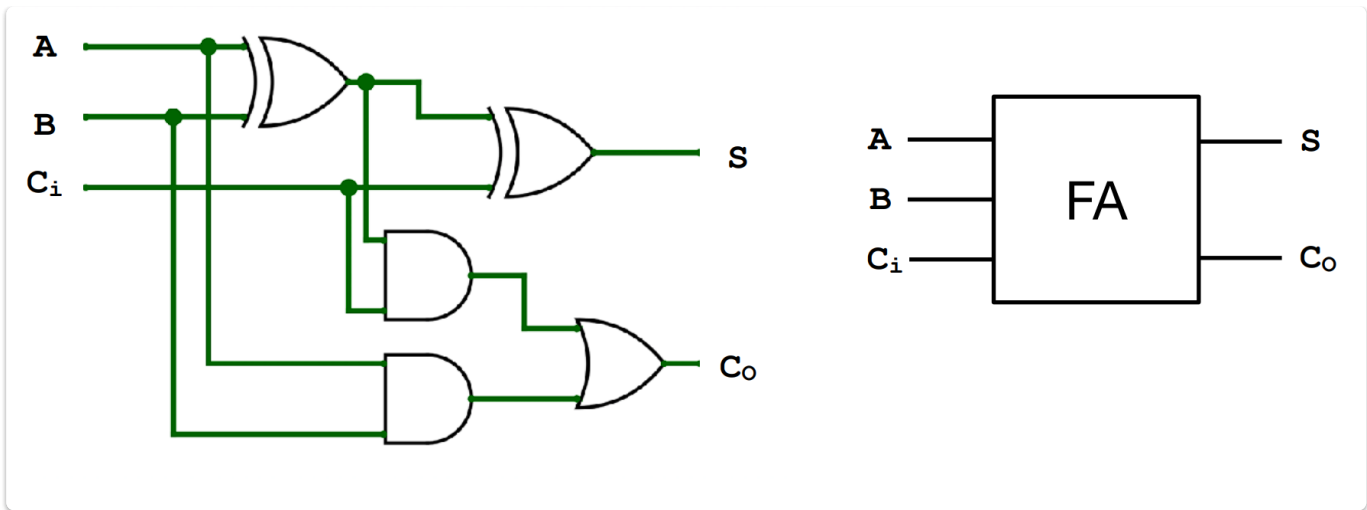
Arithmetic Logic Unit

- Carries out arithmetic and logical operations on integer binary numbers.

Multiplexors

Selects an input to propagate to the output

AND Result
ADD Result
MUX
0
out

If select = 0, out = AND Result
If select = 1, out = ADD Result

Select

A   B

AND

ADD

result

S   C_O

select line

MUX
0

out