Logic Gates

1. Label the following logic gates:

2. Convert the following to boolean expressions:
   (a) NAND
   (b) XOR
   (c) XNOR

3. Create an AND gate using only NAND gates.

4. How many different two-input logic gates can there be? How many n-input logic gates?

Boolean Logic

1 + A = 1  
A + \overline{A} = 1  
A + AB = A  
(A + B)(A + C) = A + BC  
0B = 0  
\overline{BB} = 0  
A + AB = A + B  
DeMorgan’s Law: \overline{AB} = \overline{A} + \overline{B}  
\overline{A+B} = \overline{A} \overline{B}

1. Minimize the following boolean expressions:
   (a) Standard: (A + B)(A + \overline{B})C
   (b) Grouping & Extra Terms: \overline{A}BC + \overline{A}BC + ABC + \overline{A}\overline{B}C + ABC + \overline{A}BC
   (c) DeMorgan’s: \overline{A(BC + BC)}
1. Fill out the timing diagram for the circuit below:

```
+---+ +---+ +---+
IN |D Q| s0-|D Q| s1-|D Q|--Out
  ++--++ ++--++ ++--+
  |     |     |     |
CLK--------------------------------
clk ____________________________
in ____________________________
s0
s1
out
```

2. Fill out the timing diagram for the circuit below:

```
+---+ +---+
A--|D Q| R1--|D Q| R2--
  ++--++ ++--+
  |     |     |
CLK-------|>o---+
clk ___________
!clk ___________
A
R1
R2
```

**FSM**

1. Fill in the following FSM for outputting a 1 whenever we have two repeating bits as the most recent bits, and a 0 otherwise. You may not need all states.

```
1
Start
0
```